DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

NOVEMBER 1959

2/6

Disease-free rats

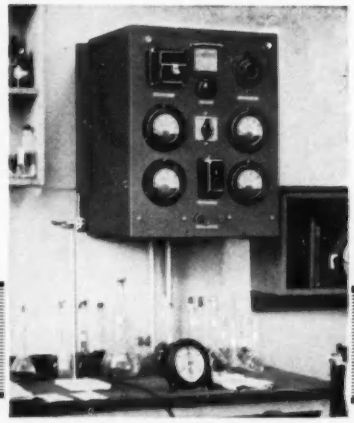
SUPPLYING THE NEEDS OF EDUCATION

Queen's University, Belfast

80 units have recently been installed in the new David Keir Building, Queen's University of Belfast.

Over 5,500 AC/DC Low-voltage Experimental Power Units, having outputs AC/DC, 40 amps at 0–14 volts, 32 amps at 14–18 volts, have been supplied to Universities, Technical Colleges, Grammar Schools and Secondary Modern Schools.

The front panel is hinged to expose the wiring and component parts for teaching, and the interlocking isolation switch renders the unit "dead" and quite safe to handle. These units meet the full requirements of Education Committees. Full technical specification will be sent on request.

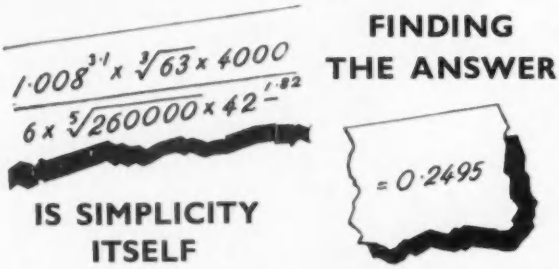


Photographs by kind permission of the Queen's University, Belfast

Legg — **EXPERIMENTAL POWER UNITS**

LEGG (INDUSTRIES) LTD · WILLIAMSON STREET, WOLVERHAMPTON

Phone: Wolverhampton 24091/2 — Grams: "Legrec, Wolverhampton"



FINDING THE ANSWER IS SIMPLICITY ITSELF

The OTIS KING Pocket Calculator makes a complex calculation seem simplicity itself. It introduces entirely new features in slide-rule design. By the use of spiral scales mounted on two concentric metal tubes, the graduations of a 66-inch slide-rule are achieved within the compass of an instrument only 6 inches long. Model K quickly solves multiplication, division, percentage calculations with four to five-figure accuracy. Model L gives logarithms as well. U.K. price 57s. 6d. Non-warping metal construction, with plastic-coated scales. Complete instructions are included with each instrument, explaining the simple three-movement operation. At all leading scientific instrument dealers or on approval by using the form below. Fully descriptive leaflet sent free on request to Carbic Ltd. (Dept. D), 54 Dundonald Road, London, S.W.19.

The OTIS KING Pocket Calculator

Send this form today

To Carbic Ltd. (Dept. D), 54 Dundonald Rd., London, S.W.19
Herewith remittance for 57s. 6d. Please send me Model .... Otis King Calculator on your guarantee that if I return it within 7 days, you will refund the money in full.

Name .....
(BLOCK LETTERS, PLEASE)

Address .....

.....

.....

UNIVERSITY CORRESPONDENCE COLLEGE

London University

B.Sc. Degree

This Degree may be obtained by examination *without residence or attendance at lectures.* U.C.C. prepares for Entrance requirements (General Certificate of Education), and the Degree exam. Courses are also provided for B.Sc.(Econ.), B.A., and various other London University External Degrees. The College is an Educational Trust with a staff of highly qualified Tutors, and in the last 70 years has enabled many thousands of students to graduate or to pass the necessary exams. for Professional or other careers.

★ **PROSPECTUS free on request to the Registrar,**

48 BURLINGTON HOUSE, CAMBRIDGE

Back Numbers of DISCOVERY

Most issues of DISCOVERY since 1951 and a few from the years 1945–50 are still available, price 2/6 each. Specific articles can be traced.

Address inquiries to:

DISCOVERY JARROLD & SONS LTD, ST. JAMES, NORWICH

DISCOVERY

VOLUME XX NOVEMBER 1959 NUMBER 11

Editor
Anthony R. Michaelis, PH.D., B.SC.

Editorial Office
11 Gate Street, Kingsway, W.C.2
CHAncery 6518

Subscription, Distribution and Business Communications to
Jarrold & Sons Ltd,
St James, Norwich. NOR 50 P

Advertisement Office
Aldridge Press Ltd,
27 Chancery Lane, W.C.2
HOLborn 8655

Copyright © 1959
by Jarrold & Sons Ltd

OUR COVER PICTURE

The animal cages where disease-free rats and mice feed and breed. They live off sterilised food, and excreta fall on to glass panels where they are flushed away by an automatic watering system.

CONTENTS

The Progress of Science 455
- Science and the New Government
- Patronage of Science—The CIBA Foundation
- Interference-Free Radio-Astronomy?
- The Problems of Old Age
- Football Pool's Millions for Research
- Chromium Finished?
- Farnborough 1959
- The Language of New Universities
- Mexican Oil and Pemex City
- Fossil Skeleton Reconstructed after 100-Million-Year Delay
- Medical Electronics
- Day-Flying Moths
- The N.S. *Savannah*

Disease-Free Rats 468
D. G. Davey, O.B.E., Ph.D.

Mechanics of Energy Transport from Sun to Earth 473
Prof. Sydney Chapman, F.R.S.

What Stake? 476
Prof. Fred Hoyle, F.R.S.

Tandem Generator for Nuclear Research 478
K. W. Allen, Ph.D.

Darwin 482
William E. Dick, B.Sc.

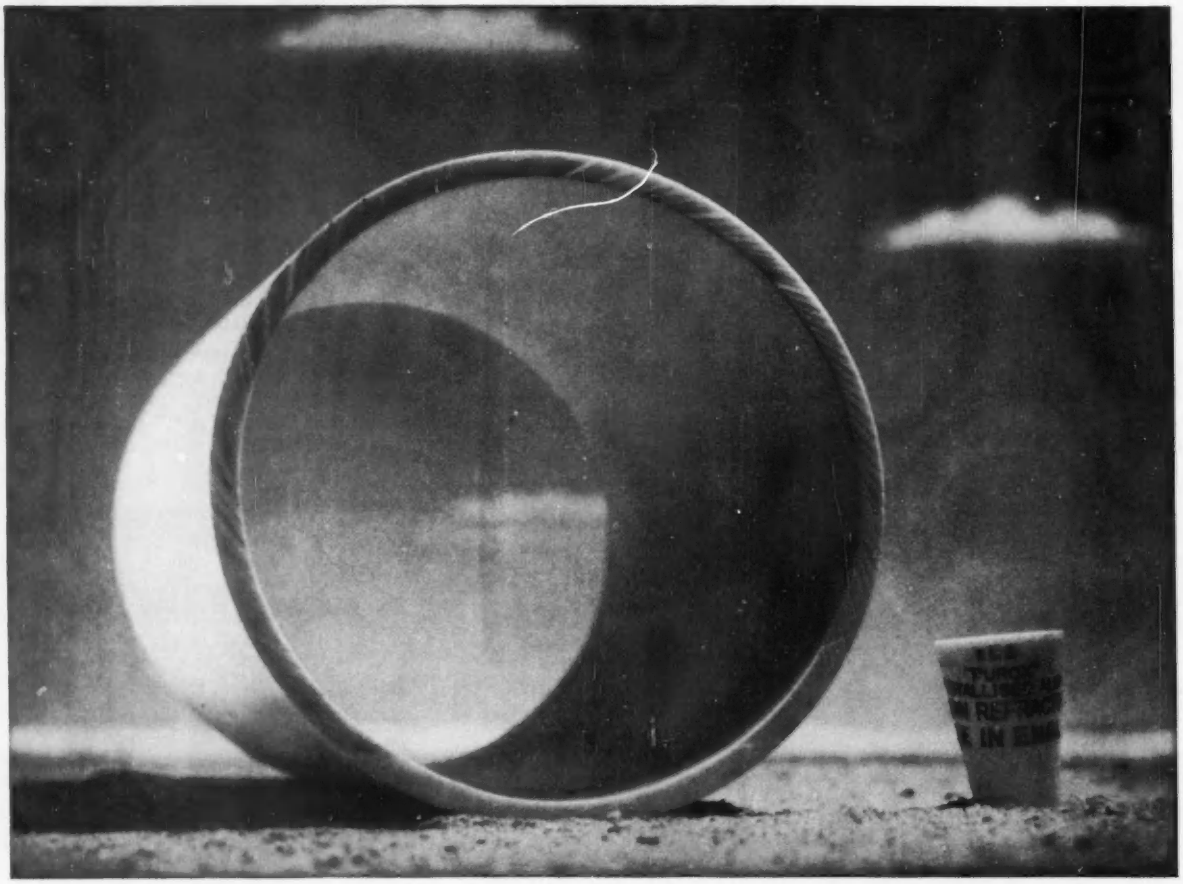
Giant Magnet 487
K. W. Allen, Ph.D.

Geophysics and Space Research 488
Angela Croome

The Bookshelf 491

Science on the Screen 495

Far and Near 499



ON THE UNTRODDEN SANDS OF TIME...

When a physicist or metallurgist in America wants to carry out very high temperature research on high purity materials where contamination of the order of even one part in a million can be disastrous, he orders his equipment from Neston. And if he works in Germany, France, Canada, Italy, Australia he does the same. Nowhere in the world have the art and science of making things from pure highly refractory oxides, been carried so far as in this Purox range of oxides. At Neston they now make these pure thoria, magnesia, and zirconia and alumina crucibles and tubes in sizes that only two years ago were impossible. They can make intricate shapes and hold dimensions to close tolerances — even though, after forming, the parts have to be fired at temperatures that make ordinary furnace refractories run like treacle. And Purox is only one of the many unusual refractories Neston make.

MORGAN REFRACTORIES LIMITED,
NESTON, WIRRAL, CHESHIRE.
TEL: NESTON 1406.

MORGAN Refractories Ltd

NE 154/A

THE PROGRESS OF SCIENCE

SCIENCE AND THE NEW GOVERNMENT

We now know that the Conservatives will govern the country for the next five years. DISCOVERY has no strict party political position, but we wish the new Government success, and particularly so we welcome the appointment of Lord Hailsham as Minister for Science. We are read by supporters of all parties, or of none. Many issues in the election concerned our readers directly as citizens, not primarily as scientists, but on one issue we have our distinctive point of view. We profoundly hope that the new Government and the new Parliament too will be well disposed towards science—for it would be idle to pretend that this should be a monopoly of any one political party. Our concern is admittedly wide. We want a Government and Parliament seized of the importance of science, prepared to devote sizeable proportions of the nation's resources to science, prepared to apply the scientific method to the solution of our problems far more intensively than hitherto, and ready to make the voice of science audible during the process of decision-making.

It is because we are conscious of these needs and conscious too of one other, the evolution of a growing spirit of understanding and harmony between scientist and layman, that in our January number this year we devoted articles by a leading Conservative and a leading Labour politician, an article by an eminent political scientist and our own editorial to a consideration of some of the most urgent problems in this field. What stands out notably from the spokesmen of our two major political parties and elsewhere in the utterances of the Liberals too, is that *all* our political parties are "pro-science" but not all in the same way, for their espousal of science clearly reflects certain key features of their party's political philosophy. Thus, the Conservative viewpoint as expressed by Sir Edward Boyle, while in many respects most forward-looking, contrives to lay great stress on the achievements of the past, insisting that "we must be very careful before we advance any claim that ours, and ours alone, is a technological age". In contrast Labour's spokesman, the Rt. Hon. Alfred Robens, was more optimistic: ". . . the application of science to industry is transforming all our lives at a speed and a pace never before realised. But even so, the surface has been but barely scratched." It is also a necessary part of Labour's thesis that the Government should play "a positive but not dictatorial role in co-ordinating the scientific direction of the country". Finally, the Liberal Party in its policy statement, "The Challenge of Automation", lays particular stress on "Expansion and growth through the *free* [our italics] workings of industry and commerce as a necessary precondition".

Support for science is not new in the programmes of our political parties. All may rightly claim to have practised their support in deed as well as in word. The DSIR was the creation of the Liberal-dominated Lloyd George coalition: the establishment of the peacetime Scientific Civil Service, the development of nuclear research, both peaceful and military, stand to the credit of a Labour administration, while the current expansion of the nation's scientific and technical manpower is an achievement of the Conservative administration. There is no reason to suppose that future support for science will be less energetic than in the past. Labour's science spokesman emphasised that "Britain will need to sell brains and not just brawn", that the crux of every facet of our advance is scientific manpower, particularly the shortage of science and mathematics teachers. This acute shortage, while also stressed by Sir Edward Boyle and Mr J. Grimond in his work on the Liberal future, should be seen in conjunction with the large number of non-scientists without any kind of scientific training, which for the future the state should aim to provide.

We for our part are acutely conscious that very much more needs to be done, not least in hammering home the lessons of the past few years. Here and now we can only treat cursorily of a few. First, the inevitable preoccupation of governments with the short-term view, while so many of their problems are essentially long-term: this is the case wherever we look—water and food supplies, transport, and energy requirements. Second, the need to improve communications between scientists and non-scientists. Partly, this reflects obscurity in scientists' ways of expressing themselves, and ignorance of science not only among politicians, but throughout the administration. This problem is not to be solved merely by expanding scientific staffs within governmental departments: on the contrary, the gulf can only be bridged—this is our third argument—by integrating science into the process of political decision-making. Contemporary history has spotlighted critical decisions—the U.S. decision to drop the first atomic bomb and to react to the Soviet *Sputnik*—which are highly scientific in character, and where the scientific advice was inadequate. There are many other provinces where the voice of science is neither sought nor heard. Fourth, we would place the use of the scientific method in studying human problems. Admittedly, some political problems are at first sight purely ethical or moral, and it may be urged that science has little to proffer towards their solution. However, here too it is necessary to consider what, given these assumptions, is the best way of solving society's problems. While science cannot claim to resolve all immediate issues of political controversy, it can throw valuable light on consequential problems of social and political organisation, down to the very operation of our democratic institutions in central and local government. Finally, an effective political system needs greater attention to the science of man both as an individual and social being. The political world abounds in generalisations about humanity: we would inquire whether these are in fact tested against man's experience in individual and social life. For ultimately it is only in this way that we can ensure that the words and acts of politicians are truly understood and cherished by those whom they represent.

PATRONAGE OF SCIENCE—THE CIBA FOUNDATION

The personal interest of wealthy men in gifted individuals has been the main source of financial support for painters, sculptors, and musicians in this and other civilizations. The same has never been true for the advancement of science. A great deal of the research work was carried out by rich amateurs right up to the Industrial Revolution, when methods of mass production and the more rigid organisation of an increasing population created many scientific workers, but relatively fewer outstanding scientists able to finance their own investigations. Since those early days of applied science, the knowledge available to any one man has become increasingly more detailed and specialised, whilst, at the same time, methods of investigation have tended towards more and more complex apparatus and techniques. Both these factors have favoured the concept of teamwork.

It is, therefore, not surprising to find that government agencies and big industrial firms are the modern patrons of science. In almost all instances their largesse is distributed by anonymous and impersonal organisations for the support of research which they have approved.

However, it is pleasant to record that a different aim and philosophy created the Ciba Foundation for the "promotion of international co-operation in medical and chemical research." A trust was set up for this purpose by the Swiss pharmaceutical manufacturer of the same name at a time when the Second World War had only just come to an end, when the continent of Europe was still shrouded in economic chaos and human misery and many millions were eking out a precarious existence as refugees or displaced persons. Very wisely the centre for this international trust was not to be in Switzerland but in Great Britain, where a general feeling of relief at victorious survival and the determination to avoid a repetition of the black depression which followed the First World War had created a lively spirit of adventure. It is also a country with a long tradition of respect for individual endeavour. The trustees of the foundation have, through their executive council, their international panel of specialist advisors and through their able director, Dr G. Wolstenholme, formulated and pursued a policy of individual help for individual scientists. It is this personal approach which has assured a special place for the Ciba Foundation in the history of medical and allied sciences.

An old Adams house in London was restored to its former beauty. It is equipped with a library, writing-rooms, dining-rooms and bedrooms, so that it can offer complete facilities for visiting scientists in London, to meet kindred spirits and to discuss common problems. The number of those who have used this "medical hotel", where free hospitality is the order of the day, has risen from 500 during the first eighteen months to well over 800 during 1958.

The house at 41 Portland Place is especially used for a large number of meetings. Many of these are arranged by and for the Foundation. Almost invariably material hospitality precedes and concludes informal gatherings of between twenty and thirty specialists who receive personal invitations to contribute their knowledge and ideas during the discussion or through the reading of short papers.

Dr G. E. W. Wolstenholme.

Frequently no record is kept and proceedings are not published.

Apart from short, informal, and unrecorded evening discussions, well over fifty international conferences, equally as informal but lasting several days, have also been held. Once more, only a restricted number of invitations are issued to ensure a truly productive exchange of information and ideas. The proceedings of these conferences are subsequently published by the Foundation. Whilst many of the conferences result from the suggestions of workers outside the Foundation, more than ten Research Fora for up to thirty members have been arranged entirely for the benefit of international organisations who would otherwise find it difficult to meet.

However, the international aspect is not unduly stressed. Some seventeen British societies, from the Hunterian Society, who have been fortunate enough to find a fitting home for their fine historical collection, to the Paediatric Pathology Club and the Scientific Publications Council, have been able to meet and advance their activities within the hospitable walls of the Ciba Foundation in London.

Apart from its special interest in endocrinology, the Foundation has, since 1954, supported research into ageing through one or two small international conferences each year with subsequent publication of the proceedings, by inviting its guests to open discussion in small groups, by a special annual lecture, and through monetary awards. An international panel considered sixty-two entries from nineteen different countries during 1958 and made nine awards of several hundred pounds each.

The Foundation has also acted on a suggestion from the Scientific Office of the French Embassy in London by awarding annual Anglo-French bursaries to doctors of at least two years' standing. Thus, in 1958 six doctors from Great Britain and four from France were enabled to continue their studies in France and England respectively.

A detailed study of the Trust reveals that almost all its aims have been carried out with singular success: to equip a house for those engaged in the study, teaching or research of all branches of the sciences of chemistry, medicine, surgery, biology, and pharmacology; to arrange lectures, conferences, and discussions; to establish and support or aid in the establishment and support of educational charitable associations or institutions; to provide funds for post-graduate research grants, to disseminate information by publication; and to arrange for exhibitions and demonstrations. If the purpose of an exhibition is to survey a field of knowledge and to demonstrate the interaction of relevant facts and factors, then the Foundation has yet to explore an aspect of its work which, so far, seems to have received little attention, but which could be of immense value in the furtherance of medicine as a whole.

Such exhibitions might well be arranged, particularly if they were to illustrate the same problem as formulated or tackled in different countries. Of even greater value, perhaps, would be an extension of the Ciba tradition of international group discussions, to examine the balance of medical research and teaching in relation to present-day world problems. Pure research will inevitably depend on the interests of individual minds. However, so much in medicine is applied research which could benefit by critical appraisal of its relative importance and by some degree of international co-ordination. Thus, for instance, immense sums of money are expended on research into the cause and cure of cancer, whilst relatively little attention is paid to rapid and increasing over-population. Another aspect of medical research is its dependence on other sciences. A number of medical problems might with profit be discussed jointly by representatives of these disciplines together with the medical experts. To each the problem will appear different according to his specialised training, experience, and knowledge. Their joint contribution may exceed all reasonable expectation, particularly in the field of methodology.

Where teaching is concerned, international co-operation may prove even more fruitful. It is here that a private and impartial body can hope to influence official opinion by wise deliberation between notable representatives of both the privileged and the under-privileged countries. It is only too well known that our Commonwealth universities, Dominions apart, are chronically short of good teachers. Anyone who accepts an overseas lecturership or professorship does so in the full knowledge that it will be extremely difficult to come back to a post of similar standing and interest. Would it not be possible to evolve a scheme whereby academic promotion in this country is conditional on satisfactory secondment to a Commonwealth university?

There are a host of similar, general and fundamentally important problems which might form a part of the individualistic approach to medical teaching and research which we have come to associate with the first ten years' work of the Ciba Foundation.

INTERFERENCE-FREE RADIO-ASTRONOMY?

It is good news that at the recent triennial meeting of the Consultative Committee on International Radio in Los Angeles, a recommendation was unanimously adopted to preserve certain radio-frequency bands for the exclusive use of radio-astronomers. Jodrell Bank's endeavours are frequently disturbed by Manchester's television transmissions though the town is some twenty miles away; radio observations from Pulkovo outside Leningrad are disturbed by interference from the busy airfield near by, and the 30-ft. "dish" at the U.S. Naval Research Laboratory has had to be shut down completely in daytime because of adverse effects from the ignition systems of the thousands of cars that drive into Washington all day. The 210-ft. Australian "dish" is to be situated in a pastoral district 200 miles from Sydney for the same reasons.

The CCIR is the international body which has the job of making technical recommendations and providing expert advice to the International Telecommunications Union (a United Nations body). The Union actually establishes the rules of international radio behaviour and enforces agreements at the political level. The ITU began a four-month meeting in Geneva at the end of August. The last such meeting took place in 1947. The enormous expansion in telecommunications and radio techniques in the past twelve years has piled up this formidable amount of business: much needs revision or review.

This ITU meeting can either make effective the proposal on freeing the important radio-astronomy frequencies from interference—or throw it out. The fact that at the Los Angeles CCIR meeting the toughest opposition, that from American commercial interests and from the Russian delegation was overcome at the technical level, gives the recommendation a better chance before the political forum at Geneva.

The details of the recommendations are eminently reasonable and mild. The radio-astronomers are not asking for the Moon. They have expressed themselves content with a 27-Mc. band-width centred on the all-important hydrogen line at 1420·4 Mc/s. Some protection is also sought for the deuterium and OH emission frequencies. Consideration is asked for clearance for some narrow frequency bands throughout the radio spectrum above 30 Mc/s.

The other important paragraph in the recommendation urges that the bands allocated for standard-frequency and time-signal emissions "should not include anything other than the standard-frequency and time-signal emissions"—so that radio workers have some chance of hearing them and calibrating their equipment.

It is worth noting that the first interference-free zone for radio-astronomy in the world was recently established in the county of West Virginia in the United States of America. This is a lightly populated farming area in the rolling uplands of the Appalachians. Throughout a region 90 by 50 miles no electricity may be made without previous consultation and agreed precautions, no aircraft may fly overhead and no power-line may pass save underground. The county authority has accepted these provisions with the greatest goodwill and will provide the necessary co-operation for enforcing them. The interference-free area takes in the recently opened Green Bank National Radio Observatory (a co-operative enterprise sponsored by a group

of east coast universities and institutes) which already has one of the finest radio-telescopes in the U.S. and will soon have another; also the site of the partly erected 600-ft. Naval Research Laboratory's "dish" whose existence has been declassified only within the last two months.

The most radical move of all to keep radio interference down has been to separate the staff of Green Bank from their cars and mount them on bicycles for getting to and from their homes and around the observatory area. Whether the Navy at the Sugar Grove site can be talked into such un-American activity for the sake of their scientists, remains to be seen.

THE PROBLEMS OF OLD AGE

WHO Report. The latest technical report from the United Nations WHO* emphasises once more that the problems of ageing in the human species are, if anything, more psychological and social than they are strictly physical. As improved medical services in the advanced countries begin to take their effect, the proportion of aged in the population has been increasing very greatly. As a result, interest is beginning to shift from the problem of how to keep people alive to the problem of how to make their additional years really worth living.

The magnitude of the second problem is emphasised by startling facts on suicide rates assembled by the WHO experts. In very many countries of Western Europe, and statistics from Australia and Canada are in agreement, the highest suicide rates among men are found in the age-group ranging from 60–75. It is interesting to a biologist that the peak period for women occurs approximately ten years earlier than for men. At first sight one is tempted to speculate that the ageing process, considered as a biological phenomenon, occurs more rapidly in the female sex in our species, despite the fact that the average total life span in the female is longer. On the other hand, when one considers additional findings of the WHO group one is inclined to be cautious about such a conclusion. Among the chief causes listed for suicide among the elderly is unemployment. We normally think of unemployment as something affecting those in the "employable" age groups. It is often overlooked that in most professions and trades enforced unemployment is visited upon all by compulsory retirement—in this country roughly around 65. The retirement of a man often removes from him both his main opportunity for social contacts and his sense of being of value to society. Can we build on this basis an explanation for the earlier suicide peak among women? For most of the women in the world, their chief productive occupation is the raising of children, and this is an activity which *does* in fact cease approximately ten years earlier than the male retiring age, with attendant loss of the same two supports of psychological well-being. It may be that this speculation, which is ours and not that of WHO, is wide of the mark, but it seems as though further study of this aspect may be desirable.

From this point of view it is encouraging that the WHO Committee recommended a number of measures designed to lessen the instability of old people by employment and the institution of old-age pensions where they still do not exist. This recommendation ought to remind us that in our own country we have a pension system which appears to be designed actively to discourage old people from engaging in gainful employment. We refer to the loss of part of the pension if the old person concerned undertakes paid work. A constructive approach to the mental health problems of the aged should surely be the opposite, namely a bonus increment to the old-age pension as an inducement to aged people to remain in paid employment. As for the size of the pension itself, the Committee found that poverty was among the factors contributing to the suicide peak among the aged. Although there is no ground for satisfaction with the size of the old-age pension in Britain (£2 10*s.* per week) the fact that there are countries in which no pension at all is paid is an even greater scandal. One can only hope that the WHO will use all its resources of publicity to bring pressure to bear upon the Governments concerned.

* "Mental Health Problems of the Ageing and the Aged", WHO Technical Report Series, No. 171.

British and Canadian Medical Association's Meeting. At a recent joint meeting in Edinburgh of the British and Canadian Medical Association a plenary session was devoted to "Problems of an Ageing Population".

All were agreed that the growing elderly fraction of the population in Great Britain is now threatening to swamp the hospital services, and that there is urgent need of public expenditure, not only to expand these services but to improve the social and home background of old people.

In the second respect, an old people's health centre, started in 1952 by Dr Nairn Cowan, in co-operation with the Western Regional Hospital Board (Scotland), has already blazed a trail. The results achieved to date were described to the BMA meeting by Dr W. F. Anderson of Glasgow, who listed improvements in the physical health, mental health, and social environment among the 1300 people over 55 who have so far attended the Centre.

The biological aspects of ageing were discussed by Prof. P. L. Krohn of Birmingham, who pointed out that natural selection cannot operate to eliminate from the population genes which have deleterious effects in the post-reproductive period of life. Such genes can therefore accumulate without much check, and may be responsible for many of the phenomena which we describe as senescence.

The individual systems of the body age at very different rates, but as Krohn emphasised in his talk, we are still far from understanding why the biological efficiency of any given system *should* decline with the mere passage of time. The biology of ageing remains a complex of unsolved problems, which will require more men and resources than are at present being brought to bear, if they are to stand a reasonable chance of solution.

FOOTBALL POOL'S MILLIONS FOR RESEARCH

Ten years have now passed since the Norwegian Council for Scientific and Industrial Research was established by royal decree, and according to the Chairman, Prof. Dr Ragnar Nicolaysen, the Council has, during this period, been granted £3,050,000 from Norwegian Football Pool funds. The aim of the Council is to promote scientific research in Norway within the human, social, pedagogic, medicinal, and natural sciences. From these funds the Council has been able to finance the construction of the Institute of Geology at the Oslo University, the cost of which was £250,000, commence the expansion of the

A section of the anodic shop of the London Aluminium Co. Ltd. A selection of items in high-purity aluminium alloy are shown being chemically polished by the Erftwerk process for the motor industry; they include large hub-caps, grills, name-plates, and trim.

Tromsö Museum to the amount of about £150,000, and construct a new research ship for the University in Bergen, as well as contributing £60,000 to the International Geophysical Year.

CHROMIUM FINISHED?

Chrome—technically chromium-plating—has now become a very familiar part of our lives. Wherever we go, in the home, office or shop, on the highway, in the surgery or bar, we find its cold, blue gleam—perhaps garish to the sensitive eye. Indeed, a chrome-less world would be hard to visualise.

But there are indications that the day may not be so far off. The popularity of chromium-plating, pre-eminent as a highly decorative and at least ostensibly durable finish for over thirty years, is showing definite signs of waning in many quarters, and unless industry comes up with some definite general improvements in quality, it may well be supplanted.

It was in 1924 that Dr Colin Fink, an American electro-metallurgist who died in 1955, gave the world the first commercial process for electroplating chromium. Hitherto, although used in stainless alloys and for yellow pigments, the pure metal was almost a laboratory curiosity.

Nickel is a fairly hard white metal with a high resistance to corrosion, although it is prone to develop a yellowish bloom in the atmosphere. It isn't difficult to plate successfully, providing care is taken preparing the work, and it will take a high polish. Fink's discovery supplied almost the ideal answer to the known limitations of nickel as a finish.

Electro-deposited chromium is extremely hard and brittle, and slow to deposit. It is not, therefore, generally practical to plate it out in sufficient thicknesses for it to serve by itself as a decorative plate, the more because it would not plate out with a highly reflecting surface. The extremely hard metal would prove almost impossible and certainly very expensive to polish mechanically.

Very thin deposits, though, about 10 millionths of an inch deep—or a hundredth of the thickness of a human hair—reproduce exactly the finish of the base metal. To highly polished nickel, for instance, the chromium imparts its own unique properties, including its colour, superlative tarnish resistance, and ability to prevent liquids and solids from adhering to its surface. Alone such a tenuous film would be virtually useless because of the gossamer-fine interlacement of cracks which permeate the deposit. These are quite invisible to the naked eye, although easily seen under the microscope; they give the atmosphere access to the underlying metal, with devastating results when this is a corrodible metal like steel or brass.

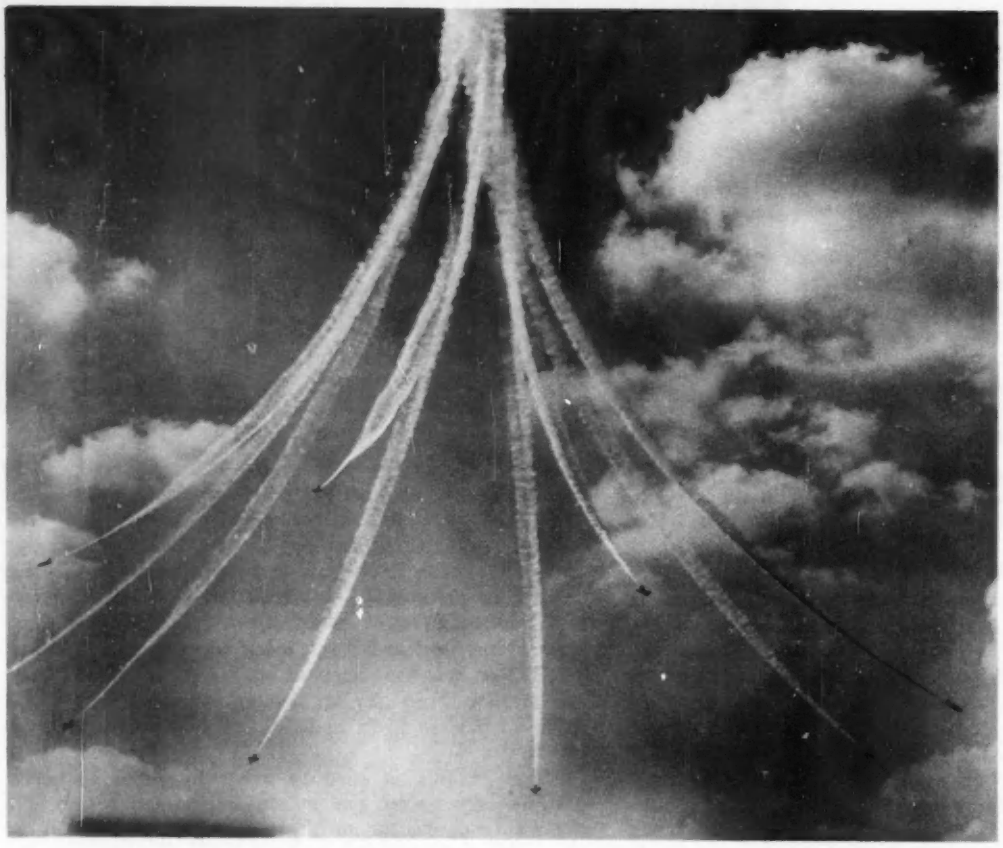
High grade chromium-plating, however, although eminently practical (witness that used on the aristocrats among our automobiles) is an expensive finish, and there is a tremendous move afoot in the motor industry away from plated steel and brass, towards polished aluminium. The U.S.A. is in the vanguard, the weight of aluminium in the average American car having increased from some 39 lb. in 1957 to 52 lb. in 1958, with an anticipated 80 lb. by 1965.

Much of this is used in trim: bumpers, hub-caps, beading. The secret lies mainly in the development of processes whereby the metal can be polished by a brief dip in a chemical mixture: to wit, chemical polishing. To achieve a highly reflective finish the purity of the aluminium needs to be very high and until recently only the super-purity metal and its alloy with magnesium (which has improved mechanical properties) gave an acceptably high finish.

In addition, the polished aluminium must be protected by anodising, which deposits a thin oxide film on its surface. In thicknesses hitherto deemed minimal for atmospheric exposure such films dull the polish appreciably but the more recent acceptance of a thinner film only 0·1 to 0·2 mil. deep means that its pristine brilliance is virtually undimmed while the corrosion resistance remains higher than all but the most costly chromium-plated finishes.

The availability of slightly lower grades of aluminium which are materially cheaper and which, with the latest, more versatile polishing solutions give comparable finishes, is further increasing the popularity of this approach. Moreover, the anodised metal can be dyed in an enormous range of primary, pastel and enamel-like hues, including "imitation chromium" colour.

The British finishing industry, although currently somewhat ahead in the development of chemical polishing solutions, has yet to apply the finish widely to motor-cars. This is partly attributable to the capital tied up in enormous automatic plating machines which could not be modified to cope with the new finish. Little doubt exists, though, that we will follow America and to a lesser extent Germany in adopting this finish very considerably in the next few years.



Hunter Aircraft of the Treble One Squadron, often called the Black Arrows.

FARNBOROUGH 1959

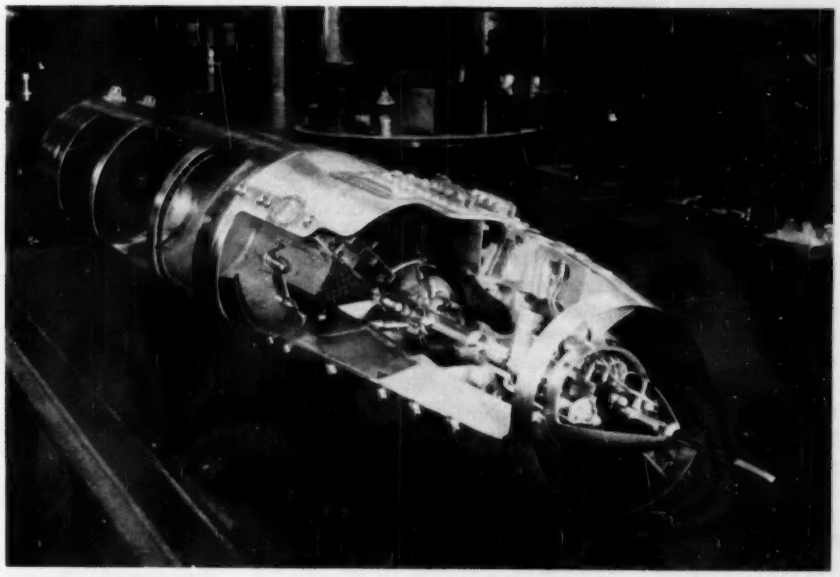
As always at Farnborough, the aircraft on display captured the main interest, but this year there was really nothing new. There were many spectacular flying displays, but the machines had been seen before. There was, however, one exception, the Saunders-Roe/NRDC Hovercraft (see DISCOVERY, August 1959, vol. 20, No. 8, p. 322), which was making its first official public appearance and was undoubtedly one of the main attractions. It was the first time such a machine had ever been demonstrated at the airfield and, similarly, the first time that a new method of propulsion with such evident potentialities had been revealed to the public since the Show's beginning at Farnborough in 1948.

During its display, the Hovercraft skated up and down the main runway at the standard 18 in. above the ground, turning at the end of its forward run, practically in its own length, to slide swiftly back to the starting-point to take on twenty Royal Marine Commandos and move off loaded almost as effortlessly as before.

The Hovercraft was brightly decorated in blue and white, thus showing how colour finishes are changing: it was disclosed by Cellon that 50% of their inquiries for the week had involved requests for information about fluorescent materials. Operators are adopting these paints in the interests of safety, for the conspicuity value of fluorescent paints such as "Blaze Orange" and "Neon Red" is high, and with the problem of aerial collisions growing the matter is important. Fluorescent materials are more costly than ordinary finishes, and last only half as long in service, but their advantages for airline and air force use outshine these other failings.

This year, CIBA (ARL) showed samples of printed circuit elements, resistors, and strain gauges based on Araldite in "potted" form. The advantages of housing electronic components in this material include freeing them from dust, and making them easier to handle and transport. Araldite has other newly proved uses: the material is well suited to the repair of damaged concrete surfaces, and could be employed as a "filler" on runways which might have suffered from the effects of jet blast. The Araldite repair can be dyed to practically the same colour as the original surface.

Turning from bonding materials to electronic equipment, the Ekco radar display was worth studying. The Ekco Electronics Company of Southend showed the latest line in airborne weather radar, which is to be installed in BEA's twenty Vickers Vanguards. This order illustrates the success of Ekco's work in the field in the last decade. The latest radar is the E190, which has a weight of 56 lb., a range of 150 miles, and comprises three units. This might be compared with the E38 of 1949, whose weight was 150 lb. and range 40 miles. These are important figures to the operator, and the present low weight and extensive range of Ekco's search radar equipment make it very attractive to airline men. The E190 operates from 400 c/s AC supplies, and facilities are provided so that it can be connected to 200-V three-phase, 115-V three-phase, or 115-V single-phase systems.

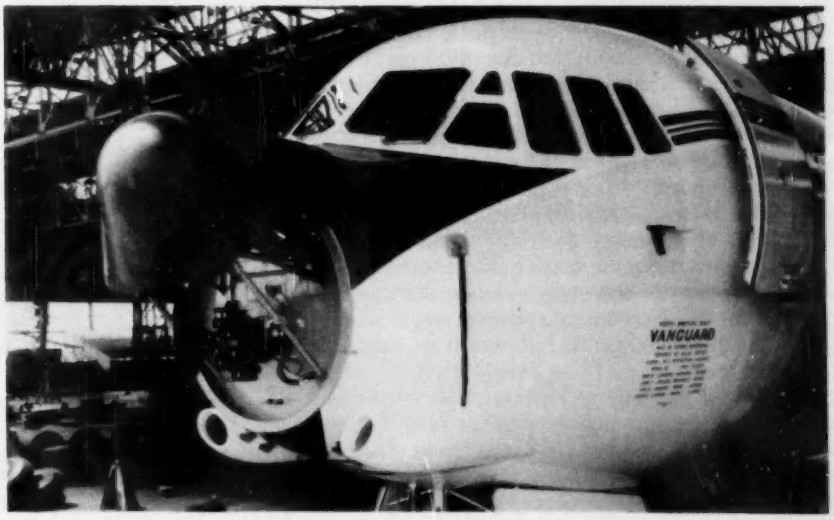


View of a Bristol Siddeley Thor BT-1 which showed, for the first time, internal details of a ramjet engine.

Another electronic device of note (demonstrated by a popular method at the Show—moving pictures) was the Ultra aircraft Crash Position Indicator. The CPI, as it is called, consists of a radio beacon transmitter based on the well-known SARAH (Search and Rescue and Homing) equipment adopted by the NATO air forces. The CPI is constructed over a thin, flat plate aerial and is embedded in tough plastic foam. It is shaped like an aerofoil section and covered with laminated nylon. In use, the CPI is fastened to some part of an aircraft, such as the tail, and in the event of the aircraft crashing, the device is thrown out, well clear of the machine. It then starts to transmit a continuous signal, enabling searchers to locate the wreck without difficulty. The CPI has been made extremely hardy, and will withstand landings on rock or ice after being hurled from the aircraft at up to 40 m.p.h. It will also float.

The Dunlop Rubber Company had an important exhibit displayed in the form of the Dunlop Air-cooled Brake. This was working on the stand. The unit is, in essence, a wheel and brake unit with a motor-driven fan incorporated in the wheel axle. The fan draws air through the wheel, thus creating considerable forced ventilation, and this reduces the temperature in the axle to such an extent that it allows turn-around times of the aircraft on the ground to be cut to incredibly short amounts. The air-cooled brake has the advantages of virtually eliminating the need for a heavy heat sink, which has always been necessary to absorb the tremendous heat generated by the wheel on landing and during braking; the new brake unit substantially reduces the tyre bead temperatures and the hydraulic fluid temperatures. This type of brake is still being developed.

In addition to these items, GEC showed a missile attitude indicator, which has been developed to measure the attitude in roll, pitch, and yaw of a *Skylark* research rocket during flight. The Ministry of Supply had a collection of interesting devices: a radio interferometer for satellite tracking, a camera for recording satellite positions with high accuracy, a display of the automatic landing system developed by the Blind Landing Experimental Unit, and an olive-green display model of the *Malkara* anti-tank weapon. As a reminder of Britain's effort in the rocket field, *Black Knight* stood outside the exhibition hall.



The Ekco Transistorised Lightweight Search Radar to be fitted in the new BEA Vanguards, weighs only 56 lb.—less than half the weight of previous systems of similar performance. The stabilised scanner is seen here in the nose of the aircraft.

THE LANGUAGE OF NEW UNIVERSITIES

In April this year a conference organised by the Committee for Science and Freedom was held in Tunis. It concerned itself with the role of the scholar in society, and more specifically, with the role of the scholar in the development of universities in the newly emerging countries. The field was further narrowed to a concentration on the universities of the Arab world, bringing the experience of other areas to bear on the subject whenever it helped the discussions.

One of the lines of discussion considered the question of how traditional universities in the under-developed countries could be modernised (this does not mean merely westernised) to become adequate for 20th century needs. The fundamental problem is that of the two cultures, the tradition of the humanities on the one hand and scientific learning and application on the other, which appear to be producing two categories of people with little in common. This problem is not peculiar to under-developed countries alone but exists in most countries today. In ex-colonial countries, however, it is further accentuated by the fact that the humanistic tradition is generally taught in the indigenous language of the country, whereas scientific knowledge is generally imparted in the language of the erstwhile mother-country, be it English, French, Dutch, or German. This is obviously so because scientific knowledge and technology were developed in Europe during recent centuries. Most of the indigenous languages of the under-developed countries are not by themselves adequate, at the moment, to cope with scientific research of a high level. At the same time, the future existence of these countries depends on providing not only enough scientists and technical experts but also maintaining scientific research.

This inevitably leads to the question of the language of instruction. National sentiment naturally demands that the indigenous language be used. Yet the practical value of maintaining a high standard in a European language has equally strong arguments in its favour. The adoption of a European language alone as the language of instruction, would result in an even greater cleavage between the educated and the illiterate, since in this case the educated would quite literally be speaking another language. A suggested solution was to adopt bi-lingualism, until such a period as the national language may be ready and adequate to take over scientific teaching and research. A case in point is the Russian example. In the 19th century, French was advocated as the language of advanced learning. Bi-lingualism enriched the Russian language to the degree of its now being in its own right, one of the foremost if not the foremost language in many of the sciences, from the point of view of advanced work and publication. Another example is Hebrew in Israel (see DISCOVERY, vol. 20, No. 5, p. 183).

Another of the many questions raised was that of the degree of governmental interference in the functioning of the universities. It was suggested that the ideal situation was one where governmental authority would provide funds for various developments, but would at the same time refrain from controlling too closely matters of university policy. It was pointed out, however, that this situation was unlikely in under-developed countries since the needs and pressures on universities were of a different kind from those prevalent in the European countries. For example, owing to the desperate need for trained personnel, particularly in scientific and technical fields in the new countries, it was inevitable that the governments in these countries would encourage this aspect of university work, as against the accelerated development of traditional education, of which there was a fair amount already.

Continuing this line of approach it was also suggested that these universities when considering the expansion of certain faculties would have to take into consideration the openings for employment and, in fact, would have continually to be in touch with the overall planning taking place in the country. Utopian universities, where scholars could isolate themselves from society for short periods in order to intensify their contemplation, were a dream of the future.

MEXICAN OIL AND PEMEX CITY

Leaving Mexico City for the oil-fields of the south-east, the plane flies over the pyramids of Teotihuacán; then later over Tajín, the Totonac temples deep in jungle where even jeeps stick fast in the rainy season. Near them, at Corpus Christi season, the *Voladores* dancers throw themselves, roped, from a 60-ft. pole, to circle planet-like about the lone central Sun, a diminutive man precariously piping and leaping on his high platform not much over a foot square.

Presently, among banana and orange groves, the burning gas-flames and the grimy derricks rise, and the oil land has been reached: Poza Rica, centre of the famous Old Golden Lane whose discovery led to the Mexican oil heyday of the twenties, and finally the fabulous Pemex City built in fourteen months on the only firm ground in the midst of marshes where canoes of hollowed trunks wend their ways among the bulrushes. Thus do geology and anthropology mingle, as is the way of Mexico.

It has been reckoned that 91·7% of Mexico's total consumption of energy comes from oil and gas. This is the largest percentage of any country in the world. In the future, therefore, it may well be that Mexico will have to look for other sources of energy: hydroelectric (already much used, see DISCOVERY, 1958, vol. 19, No. 2, p. 66); geothermic (still in an experimental stage): and even nuclear (there are promising deposits of uranium and of davidite).

Meantime, however, Mexico's petroleum industry has once more been recognised as financially stable by the foreign countries who were turned out when oil was expropriated in 1938. Recognition has taken a very practical form, loans to the tune of at least $87 million (U.S.).

These loans mean that Mexico will be able to continue to add to various already spectacular constructions. In 1956, for instance, Pemex (Petroleos Mexicanos) announced the opening of a new refinery in Minatillán, in the south-eastern oil-fields. This crude oil refinery has a capacity of 50,000 barrels daily and the first catalytic cracking plant in the Republic, though a second soon followed in Mexico City. The petrochemical industry is developing fast, and the Government has recently taken over its control, though foreign capital will be allowed to participate under certain limited conditions.

Still more spectacular was the opening in 1958 of the absorption plant of 300 million cu. ft. capacity daily, which was the central focus for Pemex City, close to the Guatemalan border and with no communications to the rest of the Republic except by air. The city is a model

This map shows the situation of Pemex City (Ciudad Pemex), and the country's main oil installations.

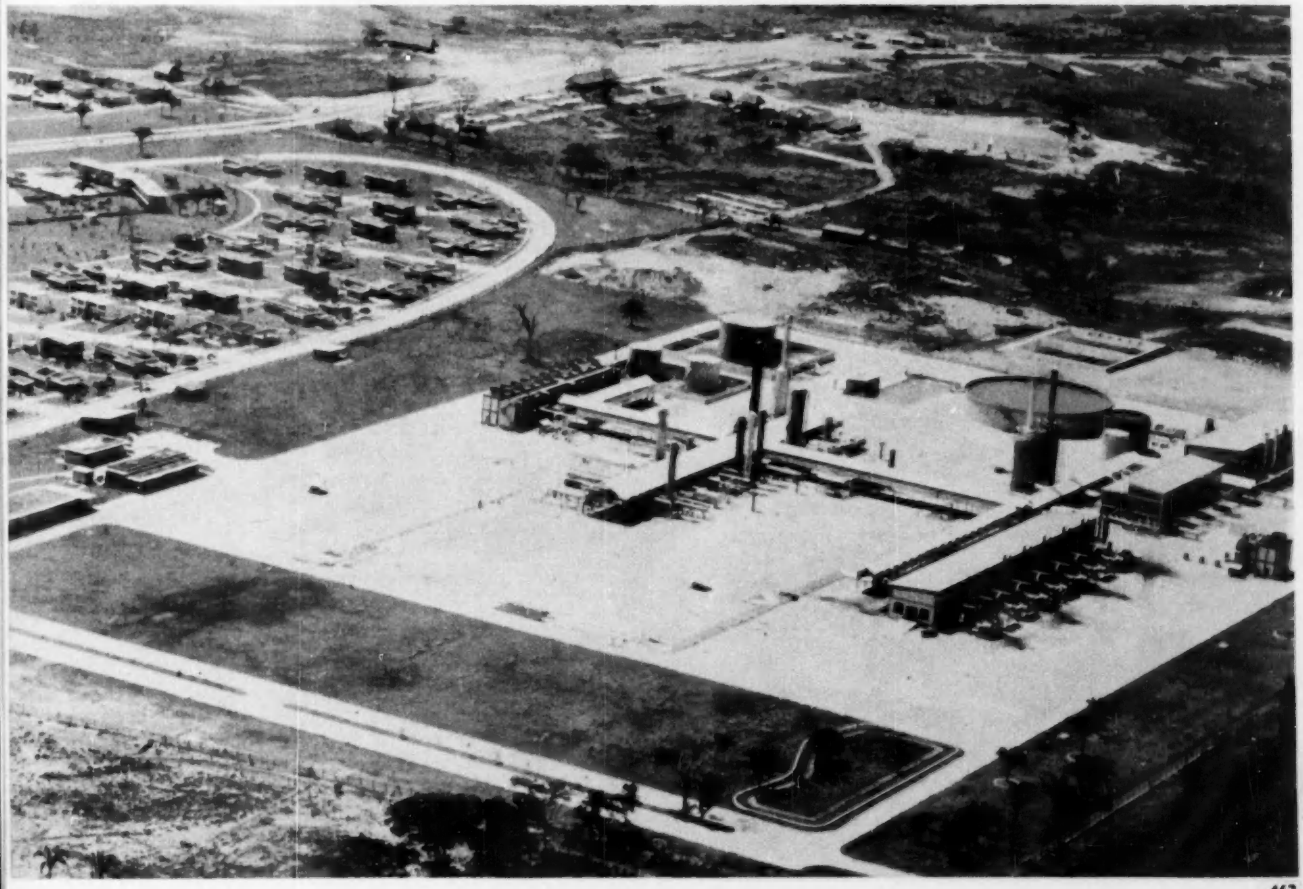
housing estate for Pemex workers in the area, very modern, with bright paint, and rows of neat bungalows.

Construction was also at once begun on a gas pipe between Pemex City and the capital, which will be 975 km. long and must cross marsh, plain and mountainous areas: a considerable engineering feat. There is already a gas pipe 249 km. long in North Mexico, serving the industrial town of Monterrey and using pipes made of a special "sponge steel" developed in Monterrey itself. This sponge steel is porous as its name implies, and is manufactured with cheap local gas and not with coal.

Pipelines run, too, from Poza Rica and Tampico to the Federal District of Mexico City, to Monterrey, and to other centres such as Guadalajara in West Mexico. In a country where earthquakes are already a danger, these are not without risk.

The new petroleum loans are tied to the purchase of equipment, which is still needed. But even more urgent is exploration. There are now 44 exploration brigades in the country as against 4 when oil was expropriated, and 160 perforation units as against 16 in 1937. The country's daily refining capacity is 322,000 barrels and reserves are calculated at 3,373 million barrels, but consumption of petroleum is still increasing faster than production and it is unlikely that Mexico will ever be a petroleum exporter as she was during the twenties.

(*Below*) Aerial photograph of the absorption plant and part of the housing estate of Pemex City.



FOSSIL SKELETON RECONSTRUCTED AFTER 100 MILLION YEAR DELAY

The fossil skeleton of what was once the largest flesh-eating reptile in the sea has been reconstructed at Harvard's Museum of Comparative Zoology after more than 100 million years. Dr Alfred S. Romer, the Director, supervised the reconstruction of the 41-ft. skeleton of Kronosaurus, which, next to the whale, is the largest marine animal that ever existed. The *Kronosaurus queenslandicus* (a species of Plesiosaur, a group of marine reptiles) must have lived during the Lower Cretaceous period in the sea that once covered Australia. When it died its remains sank to the bottom and, during the course of a million years, became slowly entombed in limestone, formed from sediments drifting down to the ocean bottom. When the water receded and the sea bed became part of continental Australia, the limestone began to be weathered by wind and water and parts of the skeleton of Kronosaurus began to show through the mantle of rock. In 1931, William E. Schevill discovered the partially exposed fossil remains and carefully blasted the rock. After the skeleton was removed, the bones were immersed in acetic acid to clean the surface, and missing bones were filled in.

MEDICAL ELECTRONICS

About a year ago details were announced of the formation by the Institution of Electrical Engineers of a Medical Electronics Discussion Group. The Organising Committee is composed of members of the medical profession and electrical engineers. The meetings have been deliberately kept informal with ample time for general discussion.

So far, meetings have been held on "Problems in the measurement of blood flow", "Problems in the field of neurophysiology" and "The physiologists' requirements for D.C. amplifiers", and "Problems of storing transient phenomena for subsequent analysis".

This brief list of topics shows that the range of subjects to be covered will be very wide.

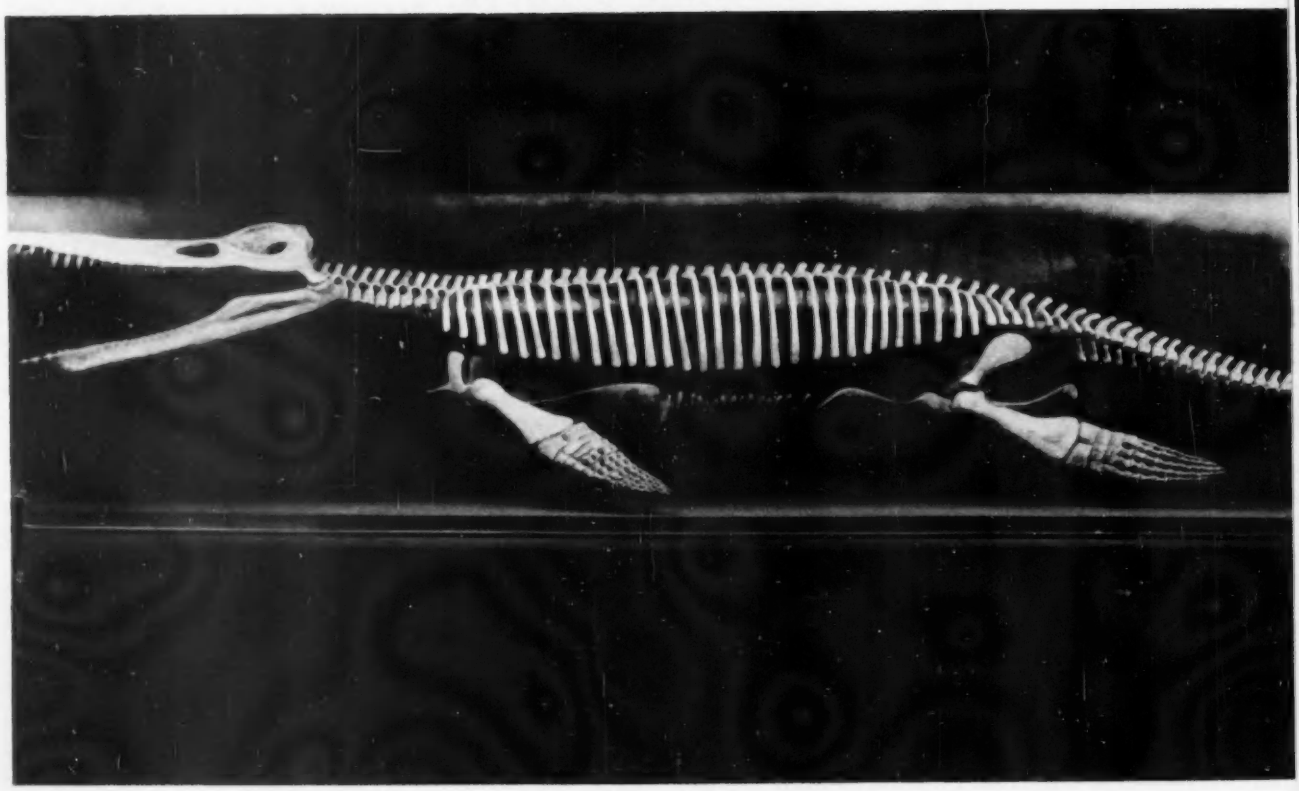
Attendances at these meetings have been large and the participants have come from all over Great Britain. Many branches of medicine and biology have been represented.

To check on the working of even a small electronic computer requires a lot of complicated equipment. It is easy to see that such an intricate organism as the human body must offer plenty of scope to equipment designers. No electrical instrument must ever attempt to replace the clinical diagnosis of a doctor, but it may help him considerably in arriving at a correct decision.

The measurement and analysis of the electrical activity of the brain requires a great deal of electronic apparatus and assists in the treatment of mental disorders. Yet another sphere of interest to engineers is the use of artificial organs such as the heart-lung machine and the artificial kidney. These devices require first-rate control systems for their efficient operation.

In recent years, electrical engineering has contributed much in the fields of automation and nuclear power to name but two examples. An active co-operation with the

The reconstructed skeleton of Kronosaurus.



medical profession should greatly benefit everyone. The Institution of Electrical Engineers is to be congratulated on providing a place for engineers and doctors to meet together.

DAY-FLYING MOTHS

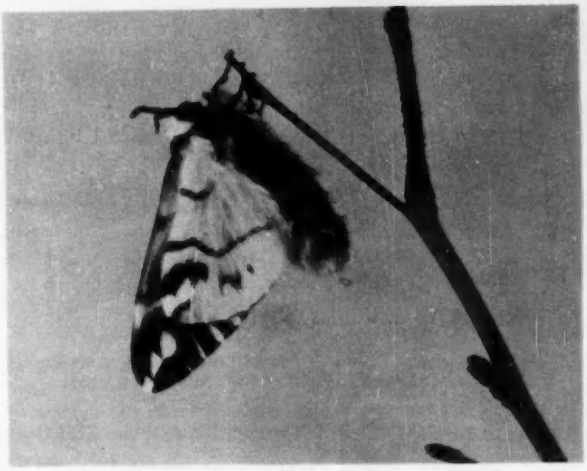
The general opinion is that moths rest during the daytime, and are active by night, but it does not apply to all species. Some moths respond to sunshine and retire in the evening, so because of this they are frequently mistaken for butterflies. These day-flying moths are not all closely related, and their behaviour varies. Some are active only when the sun shines, a few fly by night as well as by day.

The first of these sun-loving moths to appear are the two species of orange-underwings, and they fly on bright days in April. The dark orange-underwing is widely distributed, and can be seen in birch woods over much of Britain, but its relation, the light orange-underwing, is local. It is only found in woods when aspens are common, and its range is mainly limited to southern and eastern England. The orange-underwings are attractive, but they are insignificant compared with the lively and handsome emperor moth that emerges in late April and May, and haunts moorland country. The male flies mainly in the afternoon, and is swift on the wing, but the female is more lethargic and is frequently seen resting on heather. She is also a larger insect, with a wing-span of about three inches. The Kentish glory, a moth of rather similar habits, appears at about the same time, but it is not nearly as common as the emperor. Its chief haunts today are in the Scottish Highlands, for unfortunately it has died out in most of its former English ones.

Another moorland species, the oak eggar, flies in June and July, and again the males are more lively than the females. Their wings are attractively marked with yellowish bands against a background of deep rust-brown, but the wings of the larger females are paler brown. The chief concern of the males is to find a mate, and a newly emerged female often attracts large numbers of suitors. That is why this moth, and also the emperor, is often used by moth-collectors in the experiments known as "assembling."

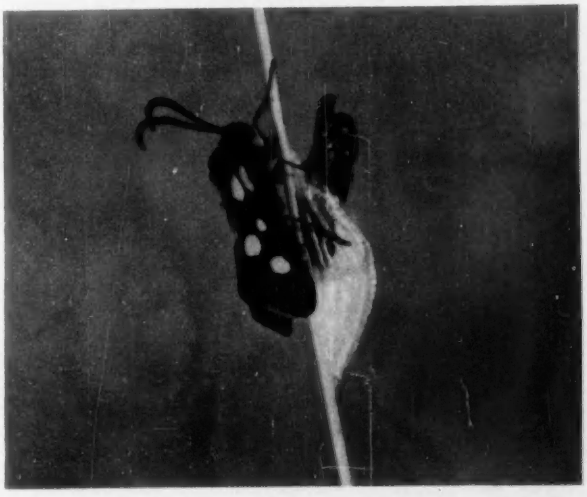
The very vivid cinnabar moth is common in May where ragwort grows. It flies in a leisurely way in sunny weather, and its vermilion hind wings are conspicuous. But they are no brighter than those of the different kinds of burnet moths which also fly by day in early summer. These have metallic green fore wings marked with red spots as well as red hind wings. The lively silver-Y moth is easily identified by the likeness of a white Y on each fore wing, and it is one of the species that takes exercise after dark as well as in sunshine. For that reason it can be seen hovering over garden flowers at noon, and may enter a lighted room at midnight.

The moths briefly described here are some of the kinds that fly by day, but others may be met with both in Britain and abroad. The swiftly moving humming-bird hawk-moth sometimes visits the garden in sunny weather, and the no less active bee hawk-moth hovers over rhododendron flowers in the woods. It might be inquired if these moths are exposed to greater danger because of their diurnal habits, but there is reason to believe that such species as the cinnabar and the burnets, which have unusually vivid colours, are distasteful to birds.

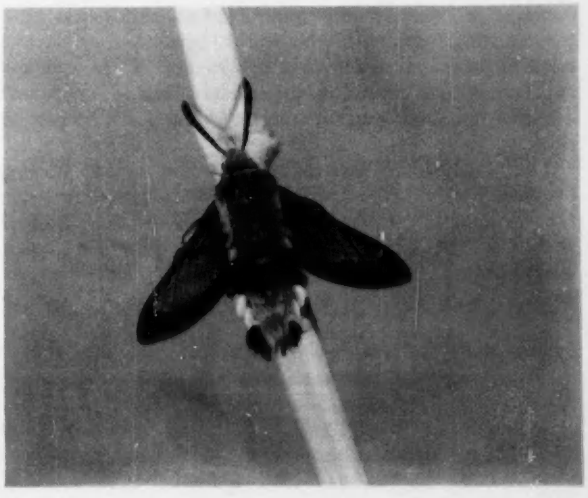


A female Kentish glory moth dries her wings.

A six-spot burnet moth shortly after emergence from the pupa.



The broad-bordered bee hawk-moth flies in woods during bright weather.



THE N.S. *SAVANNAH*

N.S. *Savannah*, showing main deck, superstructure arrangements, and position of the containment vessel.

It must first be very clearly appreciated that the 22,000-ton nuclear-powered United States merchant ship *Savannah*, launched by Mrs Dwight D. Eisenhower on July 21 of this year, is not competitive in operating cost with ships equipped with conventional methods of propulsion. She is claimed to be the world's first nuclear-powered merchant ship, although the Soviet Ice-breaker *Lenin*, (see DISCOVERY, vol. 19, No. 12, p. 498) might well lay claim to that title, if by "merchant ship" is meant a non-war-like vessel. Other than these two ships, the U.S. submarines, headed by *Nautilus*, are the only nuclear-powered vessels afloat, unless some Russian nuclear submarines have been launched without announcement.

Marine economic experts are still cautious about the future of nuclear-powered shipping: they point to the enormous capital cost, justifiable only when very large ships, with assured cargoes for every voyage, can be contemplated. They also feel that the possibilities of precipitating a disaster greater in effect than any marine accident the world has ever seen, though remote, are still present. The release of radioactivity on the scale that could occur if collision or grounding fractured the vessel containing the reactor, could involve a calamity second only to that of the explosion of an atomic bomb.

The courageous action of the U.S. Government, in allocating the vast sum of $21,000,000 (about £7,500,000) for this project should earn them (and the designers and constructors of the nuclear plant) the grateful thanks of all the maritime nations of the world: because they have in effect dedicated the ship to a programme of research and experiment, and inevitably the results obtained will benefit other prospective users of nuclear power for ship propulsion.

This single-screw passenger cargo ship is 545 ft. long between perpendiculars, and has a 78-ft. moulded beam. Her draught is 29·5 ft. when fully loaded, and the deadweight is 9990 tons, the cargo capacity being 9400 deadweight tons, or 746,200 cu. ft. She can carry 60 passengers, in luxuriously equipped cabins.

The most striking feature of her appearance is the "teardrop-shaped" superstructure, naturally with no funnel. She has three complete decks, and the 20,000 shaft horse-power provided by her nuclear propulsion unit will give her a cruising speed of 21 knots, and a field of operation of 300,000 nautical miles, over a period of 3·5 years, without refuelling.

Scientific attention naturally centres on the ship's reactor plant. The steam turbine and other mechanical equipment is of conventional design, although the latest techniques have been employed in all cases.

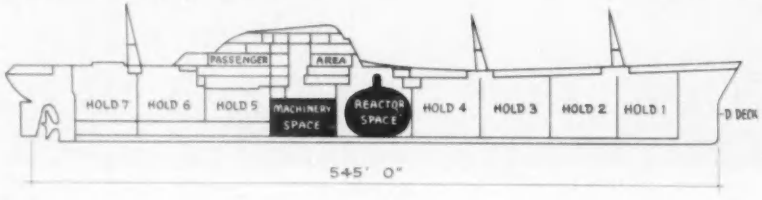
All the power-generating reactors at present in use in the United States, unlike those in Britain, and most of those in the U.S.S.R., are of the type in which enriched uranium is used in the fuel elements. This type of fuel has advantages over the natural uranium employed in Britain for the Calder Hall type stations now being built for electricity production, but the cost of enrichment is very great. In the U.S.A., the large installations designed basically for military purposes, together with the relatively cheap cost of the power needed for the enrichment process, mean that this cost problem is not so acute.

The Shippingport reactor, the only major power-producing reactor at present at work in the U.S.A., and the *Nautilus*, *Skate* and other submarines all use a pressurised water type of reactor, with enriched uranium as the fuel. The designers of the *Savannah* rather naturally follow the same path: her reactor uses uranium oxide fuel of about 4·4% enrichment, and is moderated and cooled by ordinary (purified) water, circulating under a pressure of 1750 lb. to the square inch.

The heart of the reactor (the core) takes the form of a cylinder 62 in. in diameter and 66 in. high: from this "drum", less in total volume than the smallest four-wheeled baby car, a normal operating power of 63,500 kW can be produced. The initial fuel loading of 6787·5 kg. of uranium 238 (containing 312·4 kg. of the fissile material uranium 235) will "burn up" at the rate of 7352 MW-days/ton: that is, 1 ton would (in theory) give 7,352,000 kW for one day, or 1 kW for 7,352,000 days, or any proportionate figure in between.

The thirty-two fuel elements each contain 164 rods, in which the actual fuel elements, in pellet form, are confined. The "crates" containing the rods and the rods themselves are of stainless steel.

The control of the nuclear fission reaction is achieved by lowering and raising control rods in the spaces between the fuel elements. This operation is equivalent to raising and lowering a curtain located in the stream of neutrons created by the chain reaction. The higher the curtain, the greater the heat generated: the lower the curtain, the less the heat, until the chain reaction is completely interrupted. The control rods are of crucitorm section, and are made of boron stainless steel. The boron in the steel is one of the elements that act like a sponge in absorbing neutrons.



Schematic diagram of N.S. *Savannah*.

The water which moderates the neutron flow in the reactor and at the same time takes away the heat to provide useful power is circulated through the reactor in two "loops", each containing two circulating pumps, one steam generator, two check valves and two stop valves. At full load, the water inlet temperature is 494·7°F, and the outlet temperature is 521·3°F. Some 20,000 gallons of water per minute is forced through the reactor, and delivers its heat into boilers, or heat exchangers, where water which is not in contact with potentially radioactive liquid is raised into steam, to supply the turbine.

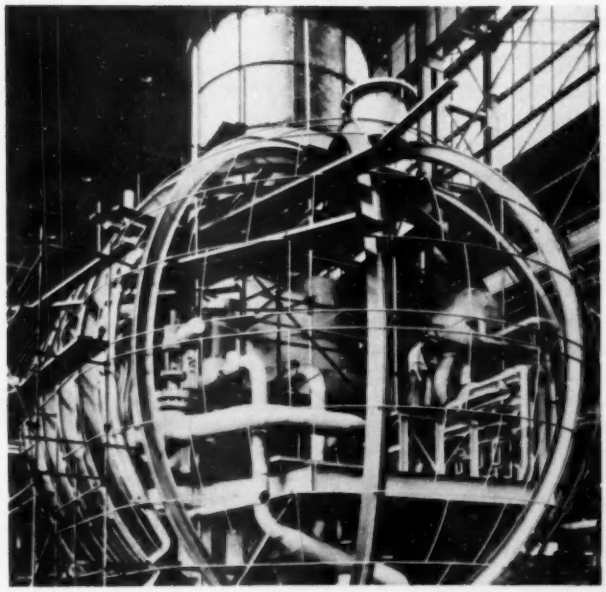
The all-important feature of a nuclear reactor designed for shipboard use is the shielding. The whole of the reactor equipment, including the reactor core, the heat exchangers and circulating pumps, is housed in a steel containment vessel, 35 ft. in diameter and 50·5 ft. long, very roughly spherical in shape. The steel is 1·24 in. at the thinnest point, and 3·75 in. at its thickest. The vessel alone weighs 275 tons.

The primary shield, nearest the reactor, is made up of a water-filled tank, and provides an encircling ring of water, 33 in. in thickness. Outside this is a lead covering, 2 to 4 in. in thickness. All this is inside the containment vessel.

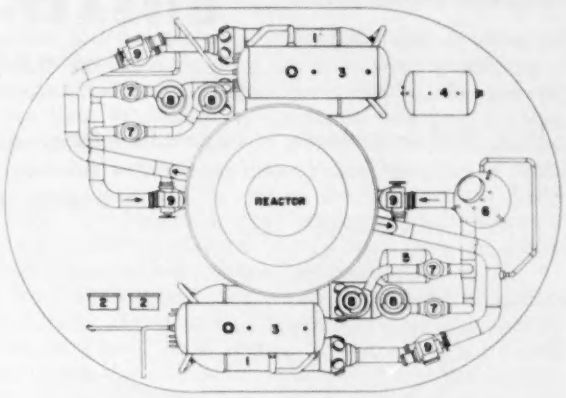
Outside the containment vesel is the secondary shield, the lower part of which consists of a concrete wall, weighing in itself 1060 tons, and in general 1½ ft. thick. The upper part is lead, between 2·5 and 6 in. in thickness. Surrounding both parts is a polythene shield, weighing in all 68 tons.

These are the main features of the shielding, which, it is claimed, will ensure that a passenger sunning himself near the swimming-pool will receive more radiation from the atmosphere than he will from the reactor: but this protection is common to all reactors, land-based or shipborne.

A full-scale model of the nuclear-power plant constructed at the New York Shipbuilding Corporation shipyard. The arrangement of components and piping is exactly the same as on the *Savannah*, and is approximately 70 ft. long and 55 ft. high. The containment vessel, is outlined in skeleton form to permit a clear view of the inside.



EQUIPMENT ARRANGEMENT WITHIN CONTAINMENT



① HEAT EXCHANGER ② LET DOWN COOLERS
③ STEAM DRUM ④ CONDENSING TANK
⑤ CONT. DRAIN TANK ⑥ PRESSURIZER
⑦ CHECK VALVE ⑧ PUMP ⑨ GATE VALVE

Plan of the N.S. *Savannah's* reactor system arrangement within the containment vessel. All primary equipment, except the reactor vessel and pressuriser, is installed in duplicate.

The special feature of a sea-going reactor must relate to the means whereby any form of catastrophe is prevented from releasing radioactivity.

The inner bottom of the ship is "egg-crated" with transverse floors at every frame, and is enormously strong. Very strong collision bulkheads are provided on either side of the reactor, and within these there are collision mats, each made up of a 24-in. thickness of alternate layers of 1 in. steel and 3 in. redwood.

The official description says that the *Savannah* was designed to withstand, "without damage to the nuclear reactor compartment, any collision with all but some of one per cent of the world's merchant fleet". (Let us hope the *Queen Elizabeth* keeps well clear.)

The ship has five important missions:

(i) To demonstrate progress in the peaceful use of the atom.

(ii) To "bring the power of the atom into the market places of the world in peaceful trade and commerce."

(iii) To prove that nuclear-powered ships are dependable and safe.

(iv) To stimulate early solutions to such problems as international liability and indemnification, and to win for nuclear ships acceptance in the world's ports.

(v) "To give the Maritime Administration and the Atomic Energy Commission the opportunity for prudently assessing the possible contributions of atomic power to the progress of the American Merchant Marine in providing shipping services on routes essential for maintaining the flow of foreign commerce of the United States."

This great ship, which will sail on her first trials in 1960, represents an experiment on an almost unparalleled scale: and whatever the limitations suggested by the fifth objective above, the whole of that large proportion of mankind which is dependent on sea traffic is bound to benefit as the *Savannah* reveals her triumphs—and her problems.

DISEASE-FREE RATS

D. G. DAVEY O.B.E., Ph.D.

Research Manager, Biological Group, Research Department ICI Pharmaceuticals Division,

Many experiments in the past have been marred by the fact that the animals tested were already suffering from disease. Laboratories in several parts of the world are now overcoming the problem by breeding disease-free animals.

FIG. 1. The special air-conditioned, insect-proofed building in which the disease-free rats and mice are bred.

Last year, in the United Kingdom more than 2½ million experiments were done on rats and mice. Such figures are available, of course, only in countries where laws governing the experimental use of animals are in force, and world figures would be a guess. Obviously, however, they would be big, and because each experiment represents an animal, the world population of laboratory rats and mice—mostly white rats and white mice—must be very big. Unfortunately, almost all of these animals are diseased in one way or another, often in several ways. The mice may have mouse typhoid, mouse pox, mouse polio, protozoa, and worms, and the majority of rats will have a kind of pneumonia as well as other pathogenic conditions.

In many ways it is remarkable that those who experiment with these animals remained oblivious of their imperfections for so long. Certainly, no good chemist would work with a dirty test-tube, which is a fair analogy. Of course, how much the imperfections of the animals will intrude themselves on the experimenter depends upon what is being done, and whether he ever becomes aware of them at all depends upon how closely he looks at the animals.

If the diseases were acute, and appeared in epidemic form throughout a colony, they would be all too apparent. But most of them exist in a chronic and so somewhat hidden form—because acute, fatal disease must inevitably burn itself out quickly. To the casual observer, therefore, most of these animals appear quite well. Their coats do not stare; they scamper when disturbed, and they breed when undisturbed. But when a long-term experiment is being done, and a stress is being imposed such as an artificial disease, the resistance of the animal is strained, the natural disease manifests itself, and a casualty results. Or if a toxicity experiment has been completed, and a pathologist makes a detailed study of the tissues of the treated animals at its termination, he becomes all too aware of the damage that is present independent of what the experimenter had done. Sometimes he finds it difficult to divorce the damage already there from that which may have been caused by the experiment and then justifiably, he complains.

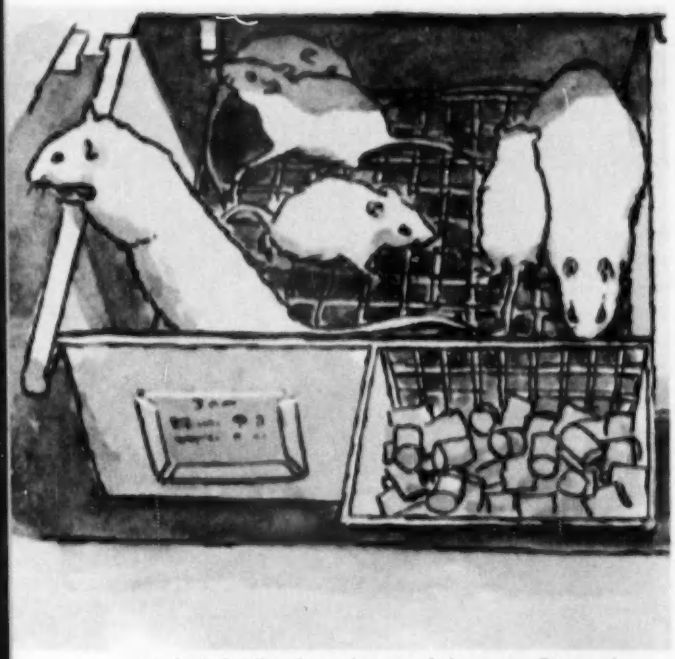


FIG. 2. A family of rats in one of the cages. One rat is drinking from a water nipple.

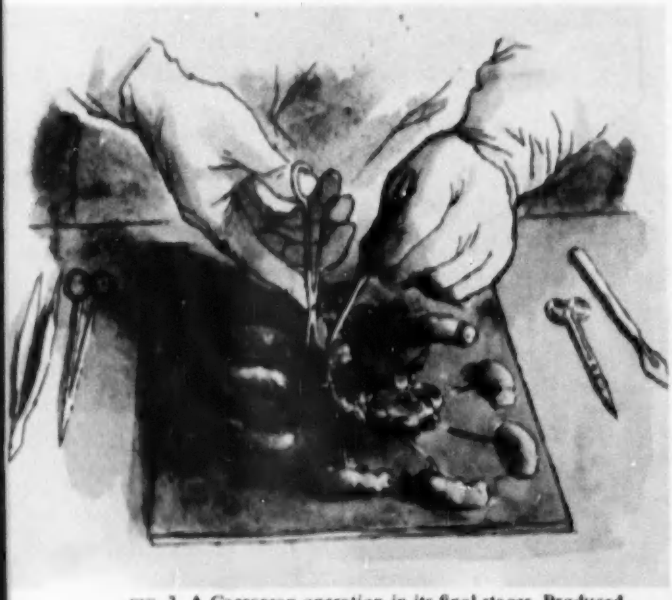


FIG. 3. A Caesarean operation in its final stages. Produced by Caesarean methods, baby rats have no chance of picking up disease from their mothers.

BREEDING FROM CLEAN STOCK

Awareness of the diseases prevalent in laboratory stock has been growing during the past few years, and several laboratories are now making a serious effort to be free of them. The only satisfactory way of achieving this object is to breed from disease-free stock, and the most direct and only sure way of getting such stock is to obtain offspring from the mother by Caesarean operation and raise them artificially. Very few infectious diseases cross the placental barrier, and the structural or functional defects which are truly inherited via the genes can be avoided by selection of the parents. The artificial raising of rats (and other animals) taken from the mother by Caesarean operation has been accomplished successfully in several laboratories particularly in the Lobund Institute of the University of Notre Dame, Indiana, U.S.A., and in the University of Lund, Sweden. The purpose in these institutes was to raise completely germ-free animals, and to keep them germ-free, objectives which were successfully attained.

But to keep animals under completely sterile conditions —which is what germ-free implies—is extremely difficult except on a small scale, because human beings have to tend the animals and are themselves infected. They carry bacteria on their skins, they excrete bacteria and viruses, and they exhale them. A room could be constructed, as it was at the Lobund Institute, to which the experimenters, clad in diving-suits and connected to an outside source of air, entered after traversing and being completely submerged in a tank of disinfectant, but such a procedure is too complicated for work on a big scale, and so, to breed rats and mice free from the diseases which are not wanted, a compromise has been made. A complete break with the disease-bearing past is achieved by obtaining the animals by Caesarean operation, and raising them artificially, but thereafter they are only kept completely free of contamination from wild rats, mice, and vermin of any kind, and the assumption is made that the bacteria and viruses they acquire from the human beings caring for them will not become established as regular, invading disease-producing organisms.

FIG. 4. Feeding the baby rats.

OTHER TECHNIQUES

In the U.S.A. a few Government laboratories, and at least two commercial dealers in laboratory rats, have started to raise disease-free animals. Most of them used Lobund rats to give them a start. That is to say, they avoided the bother of artificially raising animals by foster-mothering their own stock, taken by Caesarean operation, on to Lobund animals which were germ-free. In England, the Pharmaceuticals Division of ICI is pioneering the way, and has built a unique unit, the biggest and most advanced in design of its kind in the world, at its new research laboratories at Alderly Park, Cheshire. The ICI workers started from the beginning and did everything themselves.

The fundamental fact governing the design of the ICI building for breeding disease-free rats and mice is that a barrier has been created, as complete as can reasonably be made, between the outside world of vermin and insects, and the inside of the building. The essential features are:

1. Immediate access to the building is guarded by vermin barriers. These are T section sheet metal structures 18 in. high.

2. Personnel entering the "clean" areas must first strip, take a shower-bath, and put on clothes which have been autoclaved. The changing room where they strip has an insecticide dispenser continually in action. The curtained shower-bath is the entrance to the area where autoclaved clothes are kept. An enclosed way leads from this last area, via a three-door air-lock, to the rest of the building. The first part of the air-lock also contains an insecticide dispenser. The second part is provided with ultra-violet lights.

3. Everything else enters the clean area through autoclaves which open at both ends (one end to the dirty side, the other to the clean side), or in special cases, is taken in through Lysol. Both doors cannot be opened at the same time. Anything taken into the building is sterilised before the inner door is opened. Anything leaving the building is placed in the autoclave and the inner door shut before the outer door is opened. The inner door is not opened again until the autoclave has been sterilised.

4. There are no openable windows into the clean areas; in fact, in the animal cells there are no windows at all. This allows the animals to be kept throughout the year on a constant cycle of twelve hours darkness, twelve hours light. Ventilitation is by a stream of heated and humidified air blown through the building. Each room is provided with ducts carrying air to it, and each has exhaust ports to an extract duct. The air which enters at the intake fans is first filtered through single-thickness fibreglass, then heated, washed, reheated, and filtered again through double thickness fibreglass. The building is maintained at 70°F. The filters remove particles larger than 5 μ and possibly many that are smaller, but the air finally entering the animal rooms is not sterile.

5. The animals are fed on pellets of food compounded from wheat, barley, oats, dried milk, vitamins, and so forth. The pellets are made within the building, part of which has four floors. Raw materials are received on the top floor, and placed in the mixer-kettle of a standard food pelleting machine. Here it is heated sufficiently long to kill vegetative forms of bacteria, and viruses, protozoa, and the eggs of parasitic worms. Steam is then introduced to produce the requisite moistness in the powder to make pelleting pos-

sible. The moist powder is delivered to the floor below through a sealed-in duct to the pelleting part of the machine. This part is in a "clean" area separated from the outside world by an air-lock and a clothes-changing area with shower-bath; it is also provided with a double-ended autoclave. The food pellets are delivered to the two animal floors below by two chutes, one to each floor.

Cages for the animals, and the racks to hold them, are original in design, and much thought was given to make them not only just right for the animals, but also labour-saving for the staff. Altogether, there are about 13,000 cages. Under normal practice each cage would carry a water bottle which would have to be filled each day and cleaned frequently. This gigantic chore was avoided by incorporating a system of automatic watering into the structure of the rack. It has also been arranged for the excreta from the animals to fall on to a glass plate which can be flushed down.

FIG. 5 (*top of page opposite*). Sterilised food pellets being delivered by chute from the mixing-floor above.

FIG. 6 (*bottom of page opposite*). Feeding the food pellets into the hopper attached to the cages.

FIG. 8 (*below*). An autoclave being opened at the "clean" end.

(*Drawings by D. Michael Leonard. Reproduced by courtesy of* ICI Magazine.)

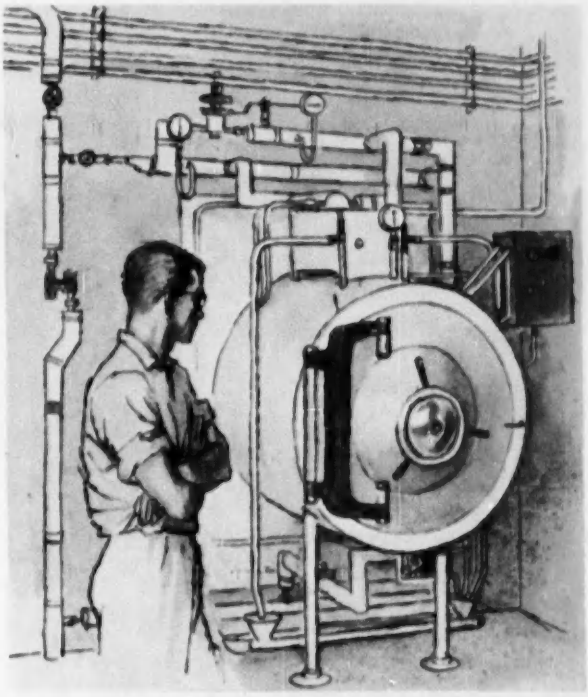
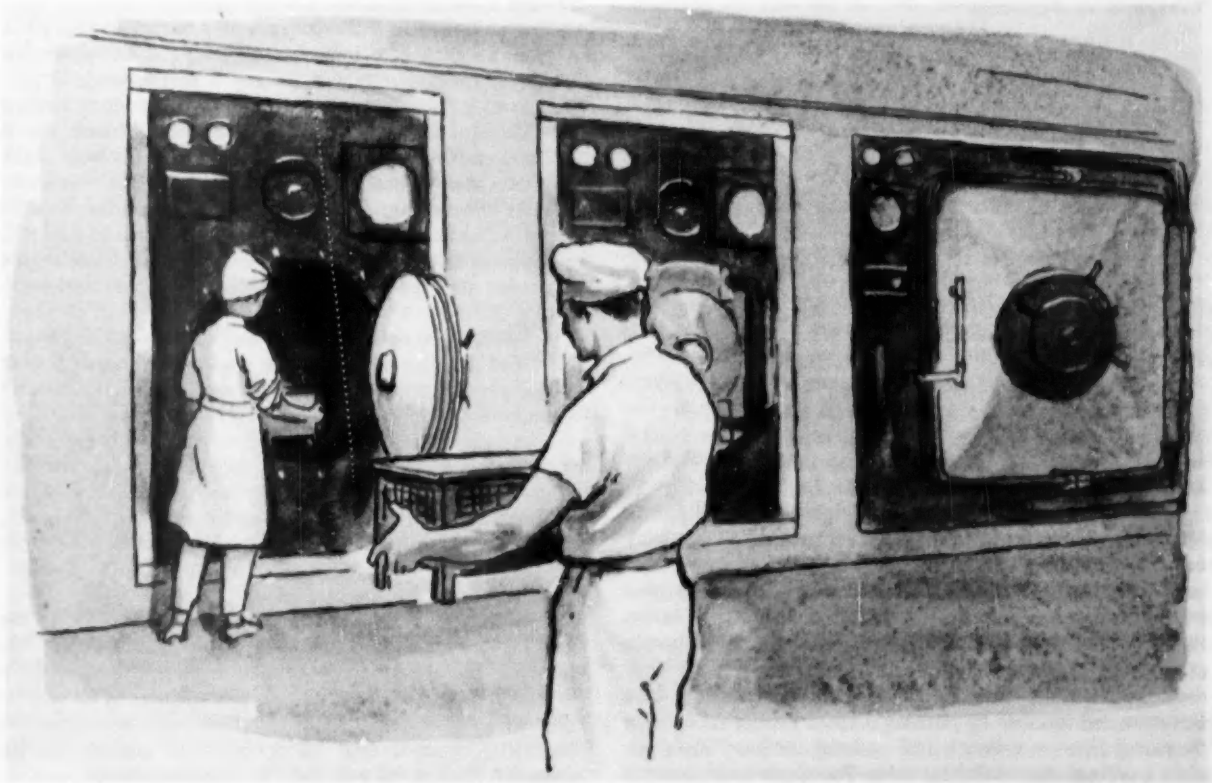


FIG. 7. Except for human beings, everything that enters the building passes through autoclaves. Complete sterilisation is thus ensured. An autoclave from the "dirty" end.



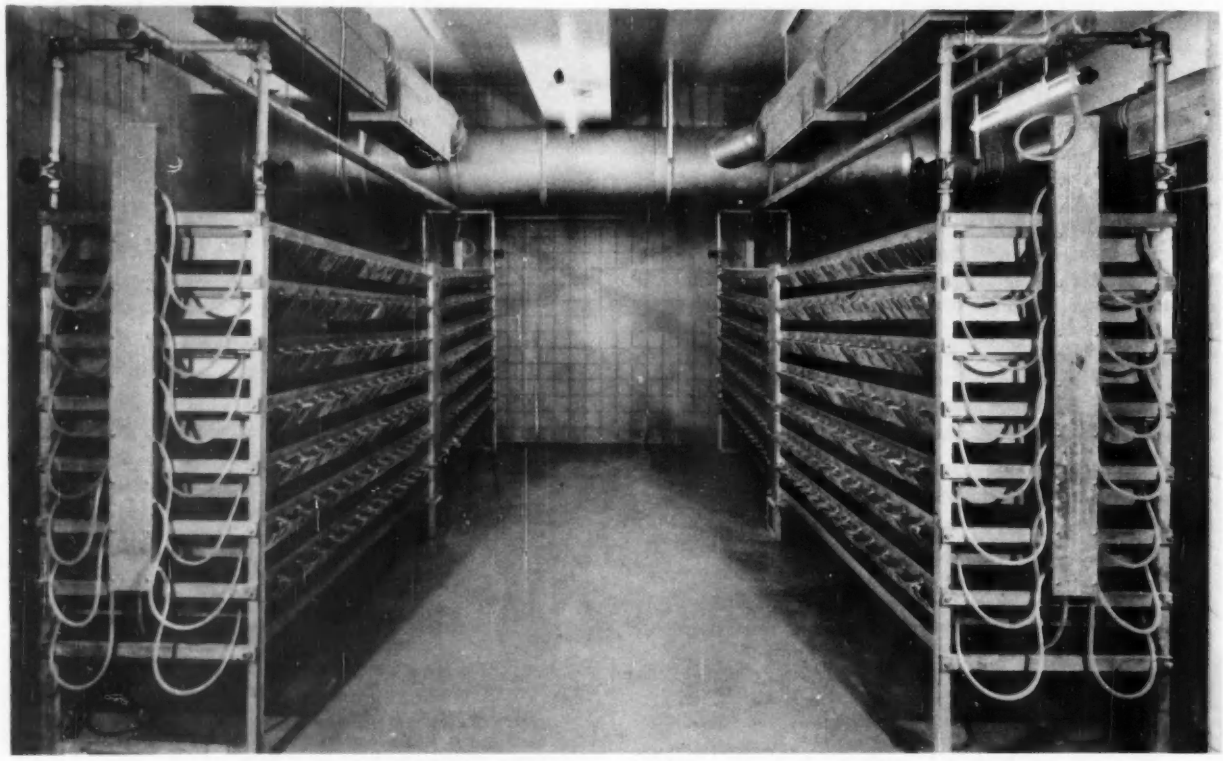


FIG. 9. General view of the room containing the disease-free animals.

TIMING SUCCESS

This is truly a special building, fit for the special animals to occupy. The nucleus of the stock now contained in the building was obtained by the artificial raising of baby rats taken from the mother by Caesarean operation. The technique used, with simple but important modifications, was that of the Lobund Institute. The first essential for success is to avoid trying to raise premature baby rats; in other words the Caesarean operation must not be done too early. Difficulties in judging the time to perform the operation arise because pregnancy in rats lasts only twenty-two days plus or minus a few hours, and to miscalculate by half a day in this relatively short time makes all the difference between success and failure. Success was finally assured by calculating as well as possible the time at which natural birth would take place, and then sitting by, waiting for the first baby to be born before operating to get the others. Rats average about ten babies in a litter, and it is no hardship to waste one.

The babies were raised within the special building with four men on shift work acting as foster mothers. They were fed on a milk diet consisting predominantly of a standard commercial preparation of dried cow's milk reconstituted with water and they were given a feed every three hours throughout the day and night. Trying to get them to suckle at an artificial teat or anything analogous was difficult, and demanded infinite patience and infinite time. They were therefore fed forcibly by pushing a small rubber tube down the throat into the stomach and squirting the food into them from a syringe attached to the tube. Too much food squirted into the stomach in this way at any one time damaged them and so each feed was divided into four or five squirts given at intervals of five to ten minutes. Rats fed like this grew almost, if not quite, as well as they would have done with their mothers. The work is demanding and exacting but not difficult, evoking no greater protest than that from a wife who complained that her husband gave far more time to the baby rats than he had ever done to his children.

When the rats are about seventeen days old they can be taught to fend for themselves and they will go to a bottle, to which is attached a narrow-bore tube, and drink their fill. Then, after a few more days they can be weaned on to a solid diet.

A sufficient number of rats was raised in this way—thirty-five females and nineteen males—to ensure getting a good cross-section of all the characters in the particular strain, and Nature is now doing the rest to make the colony of special animals big and allow offspring to be issued to the laboratories for experimental use. A colony of mice and another of guinea pigs have also been established within the building. The latter was obtained in a way similar to that used for the rats; the former was started from mice taken from the mother by Caesarean operation and foster-mothered on to the special rats.

Only time will show whether this adventure achieves the success deserved by the courage of the concept. The unknown factor is the contamination given to the animals by human beings. No one who is not apparently fit will be allowed to care for the animals, but will the organisms "normal" to man ever cause epidemic disease in the animals? The answer will come in the years ahead.

MECHANICS OF ENERGY TRANSPORT FROM SUN TO EARTH

Prof. SYDNEY CHAPMAN F.R.S.

Geophysical Institute, College, Alaska and High Altitude Observatory, Boulder, Colorado

Most of the heat received by the Earth from the Sun is transmitted by radiation. Only recently has interest been directed to the components carried by conduction and convection.

The Sun transmits energy to the Earth in two essentially different ways. The major transmission is by electromagnetic waves, which travel with the speed of light and take just under eight and a half minutes to reach the Earth. The spectrum of this sunlight shows maximum intensity in the visible region, but extends beyond its limits—on the short-wave side into the ultra-violet and x-ray region, and on the long-wave side into the infra-red and on to radio waves, whose length is measured in metres.

The small fraction of this solar radiant energy which is intercepted by the Earth energises most of the dynamical and biological processes on our planet. (The tides, energised by gravitational forces, exerted more by the Moon than by the Sun, are an exception.) This vast supply of energy is suitably expressed by a large number. In a unit used by physicists (ergs/cm.^{2} sec.) its amount at the Earth's distance from the Sun is 1·37 million.*

The Sun also transmits energy to the Earth in a more "material" way, by solar gas which is composed mainly of atoms of hydrogen, broken up (or ionised) into their component particles, protons and electrons. These carry equal and opposite electric charges, and are of very unequal masses; the positive protons have 1836 times the mass of the negative electrons.

Such solar gas is from time to time ejected from particular regions of the Sun—usually near sunspots—with high speed, so that it can traverse the distance to the Earth in a time of the order of a day or two. The speed, of order a thousand kilometres or miles per second, is far less than that of light. The ejection may give a single immense puff or cloud of gas, or it may continue for weeks, changing in direction as the Sun rotates, like water from a fire-hose swept round in a circle. If the gas impinges on the Earth, some of its energy is captured. This energy may be regarded as *convected* to the Earth, that is, it is carried by the motion of the gas.

Another "material" mode of transmission of solar energy to the Earth is by heat *conduction*. The Sun's outer atmosphere is extremely hot (its temperature is about 2,000,000°C), and its main constituent, ionised atomic hydrogen, is an excellent conductor of heat. The solar atmosphere extends far into space, to and beyond the Earth. Doubtless it rotates with the Sun at near distances; farther away it may rotate more slowly, with planetary speed. It must be much agitated by the passage of the ejected streams and clouds of gas. But all the time it must be conducting heat away from the Sun, at a rate which depends little on its density. The conduction is affected chiefly by the electrons. Near the Sun the gas is much less rare than near the Earth; hence near the Sun there are more electrons to conduct the heat, but their free paths are shorter, so that they cannot carry it far at each step. Near the Earth the far fewer electrons have longer free paths, and this makes the conductivity almost independent of the density.

* Or 1·15 kW/sq. yd.

ESTIMATING THE RATE OF TRANSMISSION

Sometimes the ejected clouds and streams of solar gas may carry away from the Sun some of its magnetic energy. As yet we do not know how much energy is thus transported, and how much is captured by the Earth. Sometimes the Sun emits cosmic rays—particles of much greater energy than that of the protons in the usual solar streams. Some of them are captured by the Earth, and give up their energy to our planet. These last two mechanisms of energy transfer from Sun to Earth seem likely to be of minor importance for the Earth's energy balance and atmospheric structure, though intrinsically they are of extreme scientific interest.

The rate of *convection* of solar energy at the Earth's distance is doubtless very variable. This is indicated by the irregularity of ejection of gas from the Sun, as reported by solar observers. Even when ejected, the solar gas may not impinge on the Earth: the occurrence of auroras and magnetic storms is taken to be evidence of such impact. But the most extreme estimates of the rate of transmission of energy by this method represent only a minute fraction of the flow of *radiant* energy at the Earth's distance. In addition to the convection by intermittent solar clouds and streams, it has been suggested (on cometary evidence) that there is a continual general outflow of high-speed solar gas from the Sun. Its proposed rate of energy transmission at the Earth's distance is hundreds or thousands of the units mentioned above as compared with the 1·37 million for the radiant energy.

The transmission of energy by heat *conduction* from the Sun is much smaller still. I estimate it to be less than a twentieth of one such unit. This is only about thirty parts in a thousand million, compared with the radiant energy.

These estimates refer to the outward flow of solar energy at the Earth's distance. They apply to any point on the Earth's orbit, for example, whether the Earth is there or not. We may think of it as energy passing by the Earth. There remains the question: how much of it can the Earth capture, and where and how? We may remember also that the Earth is in a fairly steady state, so that it does not accumulate much of the solar energy it takes in. Substantially all the energy leaves the Earth again, mostly in altered form.

ABSORPTION

The Earth's atmosphere is nearly transparent to most of the Sun's radiant energy. Some of this energy is reflected back into space by clouds in our atmosphere. Most of the

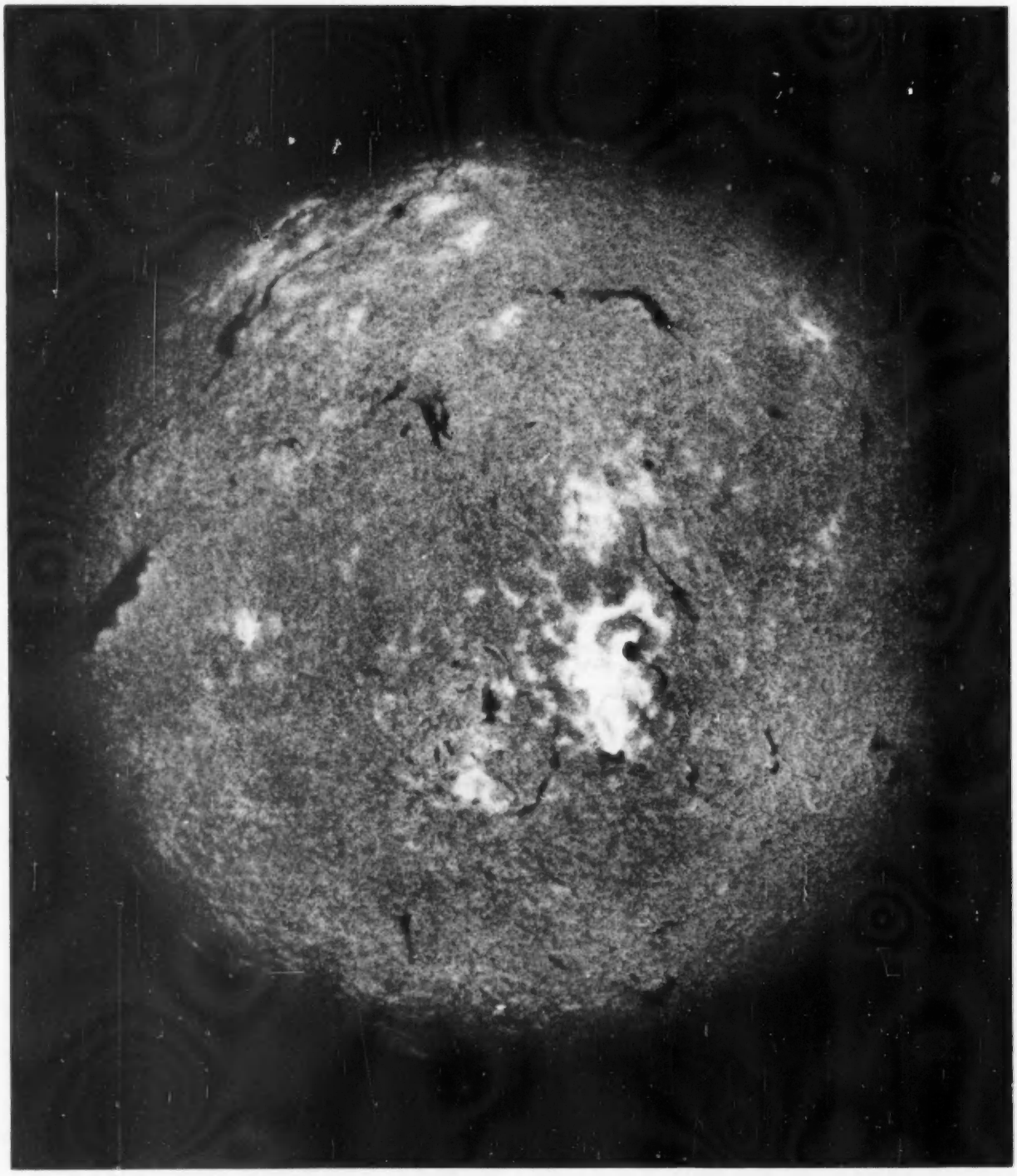
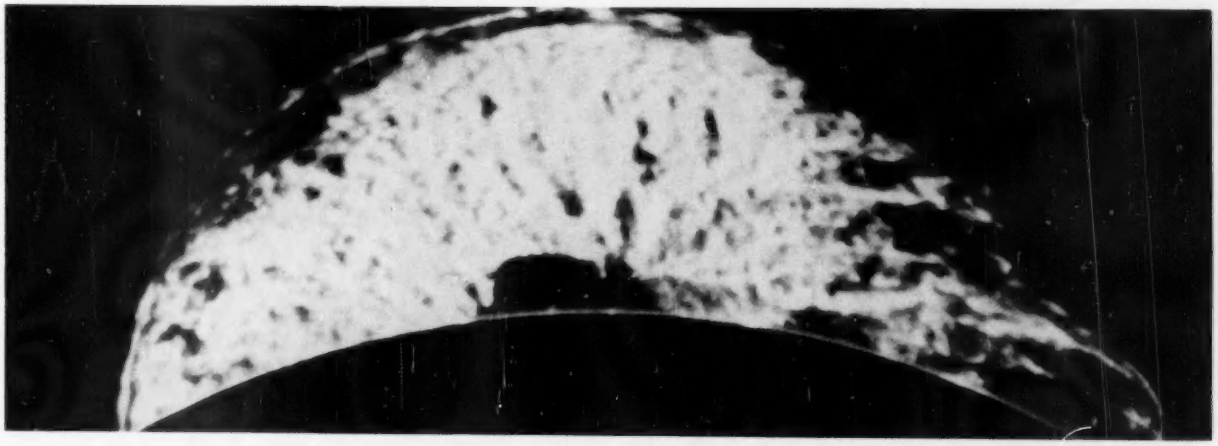


FIG. 1 (*above*). This photograph was taken at the Sacramento Peak Observatory of the U.S. Air Force Cambridge Research Center under the direction of Dr J. W. Evans. It is an exceptionally fine picture of a solar flare and was taken at 20.22 U.T. on September 18, 1957, in the red light of the Hα-line. A magnetic storm which began on September 21, 1957, may have been due to gas ejected from the Sun during the flare shown in this photograph, or, possibly, from another flare from the same disturbed region.

FIG. 2 (*opposite*). This photograph was taken with the 5-in. coronagraph at the Climax Observatory under the direction of Dr Walter Orr Roberts. It shows one of the greatest prominences ever seen, which occurred on June 4, 1946. The photograph was taken at 16.03 U.T. in the red light of the Hα-line. Probably all or most of the matter ejected fell back to the Sun, but ejected matter can acquire enough upward speed to get right away.



rest reaches the ground and is largely absorbed. Thus heated, the ground warms the atmosphere by conduction, convection, and infra-red radiation. The area over which the Sun's radiant energy is intercepted by the Earth is only slightly greater than the cross-section of the Earth itself.

However, the atmosphere absorbs a small fraction of the incident radiant energy. It does so at different wave-lengths and at different heights. Despite the fractional smallness of these parts of the radiant energy, the consequences are scientifically and economically important. This is particularly true of the ultra-violet radiation that produces an ozone layer in the upper atmosphere, shielding us from other harmful radiations; and also of the ultra-violet and x-radiation that gives us our ionosphere. This ionising radiation is at most only a few parts in a million, of the incident radiant energy.

The intake of the energy materially converted from the Sun is much harder to estimate, and we still lack understanding of how and where the Earth takes it in. Certainly most of this energy thus received by the Earth is intercepted in our atmosphere. Some of it is transformed into auroral light, some into ionisation of the atmosphere, mostly around 100 km. height or more (though it produces a little ionisation as low as 30 km.). It generates electric currents in the upper atmosphere, particularly over the auroral zones; their energy is partly transformed to heat in the high-level air. The energy is carried to auroral levels by the solar particles themselves: a few of them generate x-rays in our atmosphere that penetrate still lower, to 30 km. or less. The particles penetrate to about 100 km. height because of their high speed, which seems to be increased near the Earth in a way not yet understood—though it is believed to be due to the geomagnetic field.

THE VAN ALLEN BELTS

But some of the energy-convecting solar particles may penetrate much less deeply into our atmosphere. Van Allen has found two high belts of our atmosphere, extending across the equator from one auroral zone to the other, in which there are energetic particles, protons and electrons. The inner belt, probably created by secondary neutrons produced in our stratosphere by cosmic rays, extends from about 1400 to 6000 miles height. The outer belt, probably fed by solar particles, begins at about 6000 miles height and extends to more than five earth radii from the earth's centre.

Much mystery surrounds the fate and consequences of the Earth-intercepted energy convected to the Earth by high-speed solar gas, whether regularly or intermittently received. Many fascinating discoveries in this field may soon be expected, with the advance of rocket and satellite exploration.

It remains to consider the small energy transmission by heat conduction. This is effected by electrons accompanied by protons whose speed near the Earth is less than 100 km./sec. The electrons have greater speed but no more energy, and little penetrating power. The conducted energy is brought to the outside of our atmosphere, on all sides (not only over the sunward hemisphere). Some of it flows inwards by conduction to our cooler atmosphere and Earth. This energy traverses the air because there is an inward decrease of air temperature: it reaches any level by flowing through and affecting all the air above. It cannot overleap thick layers of air, passing through them without affecting them, as is the case with much of the Sun's radiant energy, and with some of its materially convected energy.

It seems likely that this weak conducted energy supply on the outside profoundly affects our atmosphere. The air temperature has to decrease from the high temperature of the surrounding solar interplanetary gas to the low temperature, well below 0°C, at 80 km. height in our atmosphere. This fall of temperature extends over an immense distance. The radius to the outside of our atmosphere may be as great as 50 to 100 earth radii, implying that our atmosphere may extend far towards the Moon, or even envelop the Moon. Thus the Earth and its atmosphere may be comparable in size with the Sun, as this is commonly regarded —though in like manner, taking account of its extended atmosphere, the Sun is immensely greater, and envelops the Earth.

This great extension of the Earth's atmosphere enables the Earth to draw on a greater part of the Sun's weak flow of conducted heat. Heat is flowing downwards through the ionosphere. Some of this comes from radiant energy absorbed there, but this may not be the major share. Some will come from the energy materially convected from the Sun, and some will come from the conducted energy. It is a problem of great interest to estimate the respective contributions to this ionospheric heat flow derived from the Sun's convected and conducted heat.

WHAT STAKE?

Prof. FRED HOYLE, F.R.S.
St. John's College, Cambridge

Britain is not rich enough to be a major military power, but she can be a major technological power. If some of the money now spent on defence were redirected to basic research, the investment would soon pay a handsome dividend.

Consider the following propositions:

1. That we must expect the world of the year 2059 to differ from the world of 1959 just as drastically as 1959 differs from 1859.
2. That our prosperity in the century ahead would be assured if Britain could recapture her old position as world leader in science and technology.
3. That history shows few examples of the technologically most advanced nation being defeated in war.
4. That it is no more possible to predict the changes of the next century than it was possible in 1859 to predict the changes of the last century.

I propose to accept these statements as self-evident. There may be objection, perhaps, to (4), but I know of none that cannot be well answered. An example of the validity of (4) can be taken from the last fifteen years. If physicists had been asked in 1944, "What do you expect the outstanding application of electronics in the immediate post-war years to be?" I do not believe that one in ten would have given the correct answer—the digital computer. The conventional answer would have been "radar".

Proposition (4) shows that scientific and technological pre-eminence is not to be achieved by trying to pick certain winners—the only certainty is that apparent favourites are not very likely to be the real winners of the future. A wide scientific net must therefore be cast. Everything new must be considered carefully, whether it looks important at first sight or not. This is the tap root of the argument for basic research.

THE LONG HAUL

Development research has great importance on a short scale, say ten years. But over-emphasis on development research at the expense of basic research must soon lead to fossilisation. Development research is in fact being markedly over-emphasised today, in Britain, in the U.S., and the U.S.S.R.—wherever governments are exercising a controlling influence. From a human point of view this is natural enough. Everybody prefers a clear-cut proposition offering a quick return to a largely undefined venture without hope of immediate profit. Yet this common-sense view is wrong. The financing of scientific research ought not to be regarded as a search for obvious winners. Rather should we think of a roulette wheel slightly biased, say in favour of black. Bet systematically on black, and, while there will be many losses, on the long haul you will win; most important you will win as much as you please if only your stake is high enough.

This brings me to the main point: what should the stake be? One need not travel in Asia or the Orient to discover the fate of the technologically backward—it can be seen in the faces of children in the streets of Naples. What stake will you offer to ensure that your grandchildren or your grandchildren's children, are not reduced to a like condition? One per cent of the national income? Half a crown out of the weekly pay-packet? Five per cent? Or are you so selfishly concerned with grabbing a maximum of present comfort that you are willing to settle for the Government's miserable and useless 1/20th of 1%?

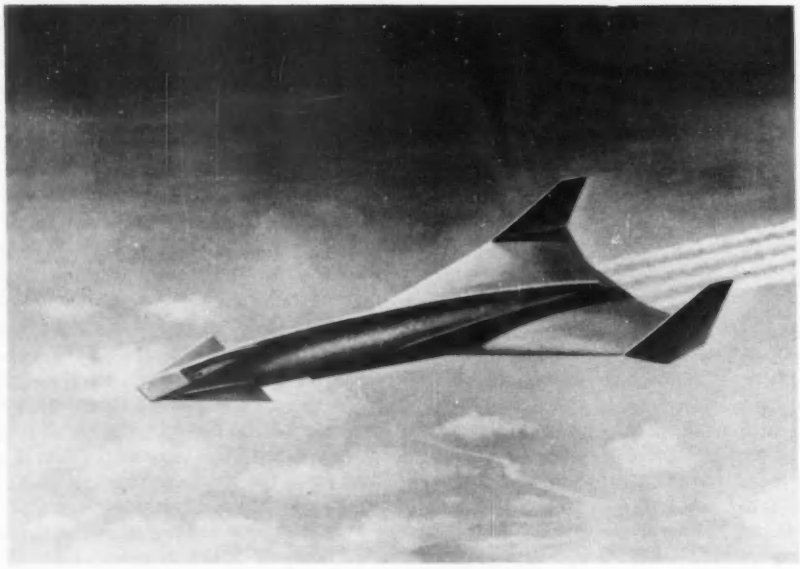


FIG. 1. **The Technological War.** An artist's conception of a passenger transport of the future—cruising at three to five times the speed of sound at 60,000 ft. or higher. This is one of many drawings considered by Convair Division of General Dynamics Corporation at San Diego, California, in its studies of supersonic airliners. It has been predicted that airline economics would compel aeronautical technology to by-pass Mach 2 transport by 1965 in favour of Mach 3 to 5 transports in the 1970s.

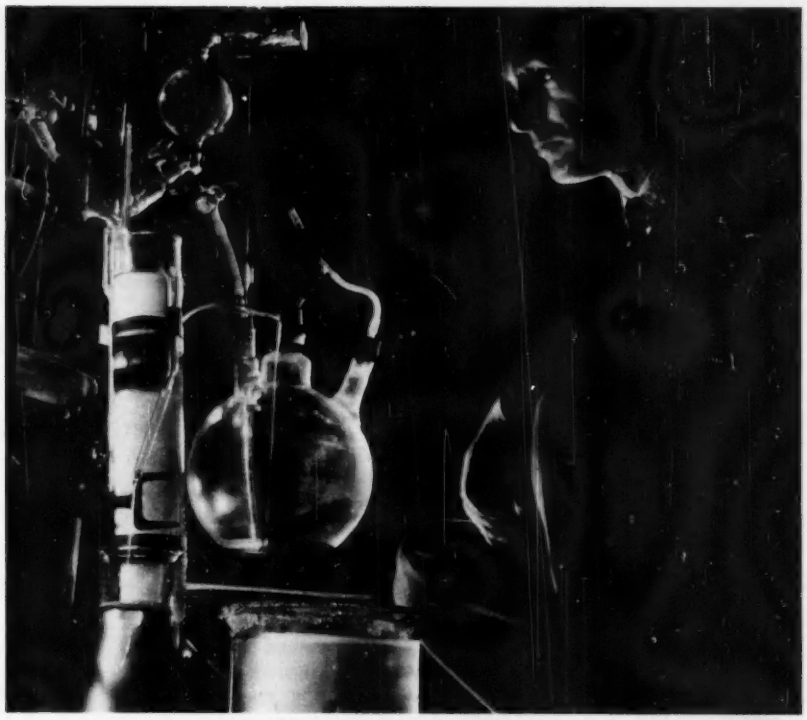


FIG. 2. **The Technological War.** Basic experimental work on silicones in the ICI Nobel Division research laboratories. The picture shows a controlled hydrolysis in progress.
(Photograph by courtesey of ICI)

I believe that a sensible value would be about 3%—about £450 million a year. How far would this carry us? Science in Britain would then be better endowed than science is in the U.S. or the U.S.S.R. We should indeed be in a financial position to attract every outstanding scientist in the world to this country—so little does the key to the future cost.

This sum may seem small in relation to the vast space research allocations that have recently been made in the U.S. But only a small part of space research is today basic: the part concerned with the design of new instruments and experiments. Most of the expense of such programmes lies in development rocket research. A nation such as ours is under no compulsion to engage in every expensive form of development research. Whether we decide to spend large sums in order to follow the Russians and the Americans in the techniques of rocketry is a matter for separate judgment. What we emphatically cannot afford to do is to fall behind the U.S. and the U.S.S.R. in basic research for the future.

INSURANCE FOR THE FUTURE

The prizes to be won through scientific leadership are well shown by the digital computer. Because both basic discoveries and essential developments belong to the U.S. in this field, the best we can do here in Britain is to manufacture our own computers—we have no serious hope of capturing the world market. But had the lead been ours, the world market, worth some £100 million a year with every prospect of a rapid expansion during the next decade, would also have been ours. The fact that the prize in just this one case is already becoming comparable with my 3% shows that the order of magnitude is right. It also reveals the irrationality of the 0·05% provided by present and past governments.

What is to be done? To make a start, it would be useful if we could be told why present expenditure is so small. My guess is that its insignificance may come as a surprise to responsible politicians, partly because of an accounting system in which basic research is too closely associated with general education, and partly because of frequent confusions between basic and development research. Although organisational convenience will probably always require some association between basic research and education, it is important to realise that, while basic research is an insurance for the future, education is a present service to the whole community. The social implications are quite different, and the financial charges should not therefore be confused.

I can well imagine the Chancellor being staggered at the thought of providing the best part of £500 million a year for basic research. Where would it come from?

At the moment we are spending some £1500 million a year on defence. This sum should be equally divided between basic research, development research, and the production of the weapons of the moment. While I can sympathise with the attitude the Services would take to such a proposal—the human problems would not be small—both logic and experience support the proposal.

The plain fact is that Britain is not rich enough to be a major military power, but she is rich enough to be a technological power. If a world war were to start tomorrow the £200,000 million or so spent on the Services since 1945 would avail us little. Moreover, we are already plunged into perhaps the most deadly war of all—the technological war; and in this war, the real war, we are not being provided with any weapons at all.

TANDEM GENERATOR FOR NUCLEAR RESEARCH

K. W. ALLEN, Ph.D.

Senior Superintendent of Nuclear Research, Atomic Weapons Research Establishment, United Kingdom Atomic Energy Authority, Aldermaston

This new technique allows particles to be accelerated to high energies by using the same potential difference twice-over. This is done by changing the charge on the particle from negative to positive half-way along the path.

It is now twenty-seven years since Cockcroft and Walton, working in the Cavendish Laboratory at Cambridge, demonstrated the disintegration of the lithium nucleus by protons accelerated to energies of 300 KeV* in a high-tension apparatus. Even before this, in 1930, Rutherford had stated his requirements for a nuclear particle accelerator. In the course of the opening of the then new high-tension laboratory at Metropolitan-Vickers, he said: "What we require is an apparatus to give us a potential of the order of 10 million volts which can be safely accommodated in a reasonably sized room and operated by a few kilowatts of power. We require, too, an exhausted tube capable of withstanding this voltage. I recommend this interesting problem to the attention of my technical friends. I see no reason why such a requirement cannot be made practicable by the use of oil or air under high pressure, but these are problems for the future." With the successful development of tandem electrostatic generators, these requirements have been met, and a powerful new research tool is available for physicists concerned with the study of nuclear structure.

In their early work at Cambridge, Cockcroft and Walton used a condenser rectifier arrangement to get the high voltage they needed for their experiments, and at about the same time, E. O. Lawrence of the University of California was developing the cyclotron. In recent years, however, it is the electrostatic generator, usually associated with the name of Robert J. van de Graaff, which has emerged as the most flexible instrument for the production of neutrons of controlled energies and for the detailed study of nuclear reactions. In the electrostatic generator, the type of ion accelerated (proton, deuteron, α-particle, etc.) and its energy can readily be varied, while at a given setting the energy of the particles may be held constant to about 1 part in 5000. This accurate energy-control is very necessary, because the study of nuclear reactions has got well beyond the rough-and-ready stage, and precision is the keynote of the experiments we must now carry out to test the theories of nuclear structure.

The principal limitation of the orthodox electrostatic generator is that voltages greater than about 6 MV are difficult to attain in practice. For a heavy element such as lead, the positive charge due to the protons within the nucleus repels the bombarding proton or deuteron, and it is unable to penetrate to the nuclear surface unless its energy is in the region of 12 to 14 MeV. With the tandem generator these higher energies are possible, and the nuclear physicist will be able to study the heavier elements with the precision which, up to now, has only been attainable with the light- and medium-weight nuclei.

* One KeV is the energy required by a singly charged particle moving through a potential difference of 1000 volts. Similarly, 1 MeV = 1000 KeV.

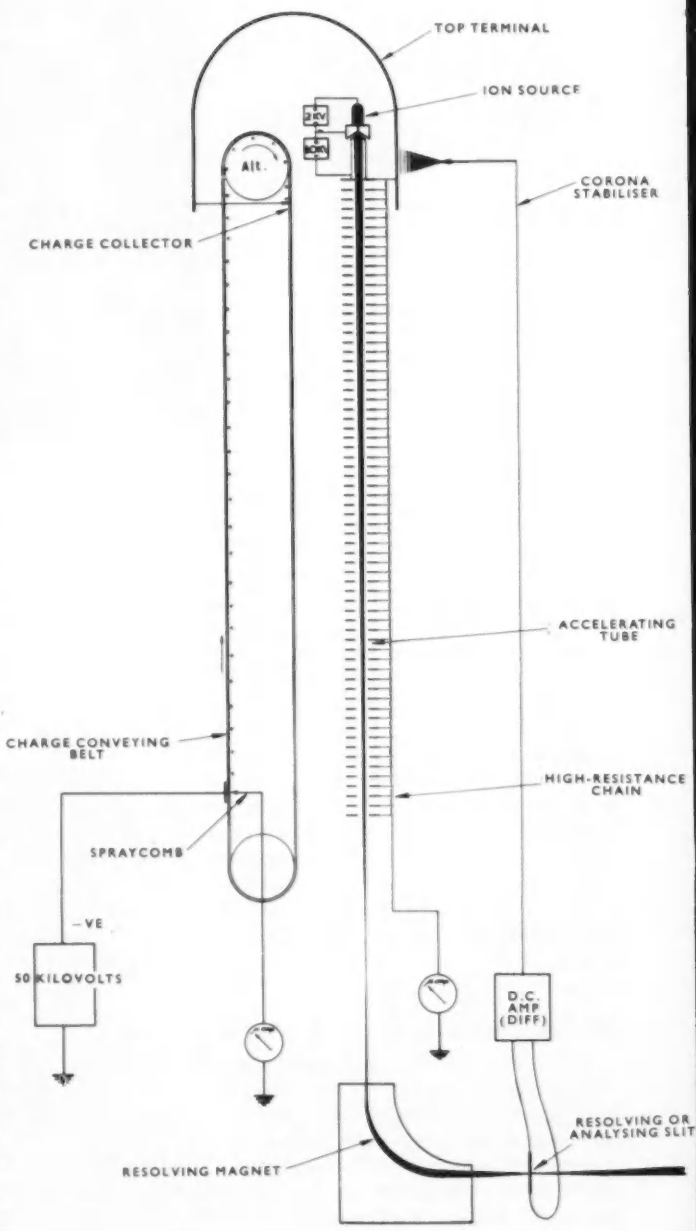


FIG. 1. Schematic diagram of 6 MeV pressurised van de Graaff accelerator. (The pressure tank surrounding the accelerator is not shown.)

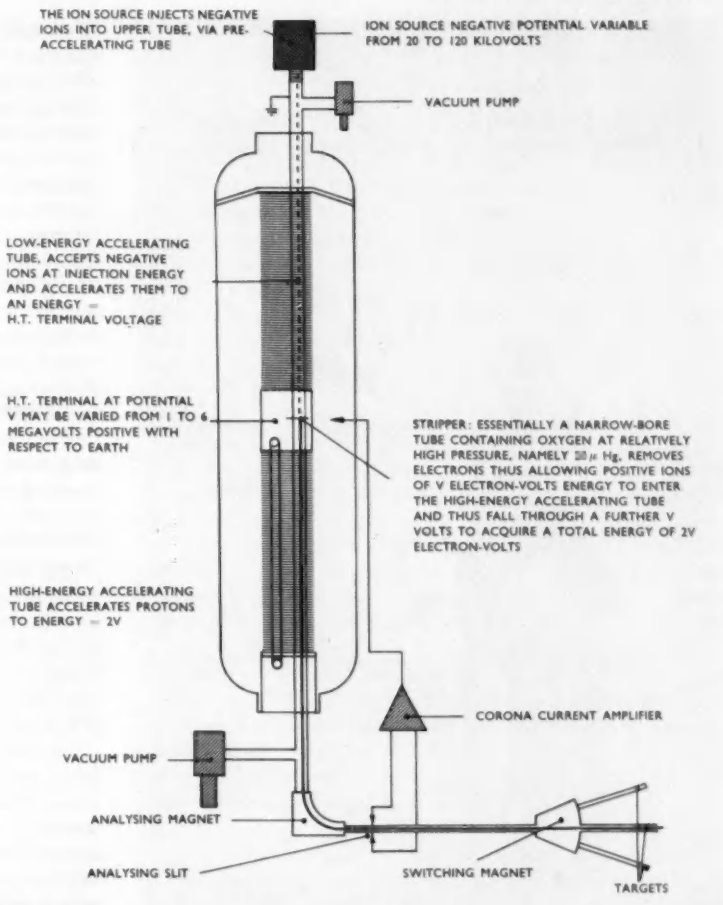

THE ION SOURCE INJECTS NEGATIVE IONS INTO UPPER TUBE, VIA PRE-ACCELERATING TUBE
ION SOURCE NEGATIVE POTENTIAL VARIABLE FROM 20 TO 120 KILOVOLTS
VACUUM PUMP
LOW-ENERGY ACCELERATING TUBE, ACCEPTS NEGATIVE IONS AT INJECTION ENERGY AND ACCELERATES THEM TO AN ENERGY = H.T. TERMINAL VOLTAGE
H.T. TERMINAL AT POTENTIAL V MAY BE VARIED FROM 1 TO 6 MEGAVOLTS POSITIVE WITH RESPECT TO EARTH
STRIPPER: ESSENTIALLY A NARROW-BORE TUBE CONTAINING OXYGEN AT RELATIVELY HIGH PRESSURE, NAMELY 20 μ Hg, REMOVES ELECTRONS THUS ALLOWING POSITIVE IONS OF V ELECTRON-VOLTS ENERGY TO ENTER THE HIGH-ENERGY ACCELERATING TUBE AND THUS FALL THROUGH A FURTHER V VOLTS TO ACQUIRE A TOTAL ENERGY OF 2V ELECTRON-VOLTS
HIGH-ENERGY ACCELERATING TUBE ACCELERATES PROTONS TO ENERGY = 2V
CORONA CURRENT AMPLIFIER
VACUUM PUMP
ANALYSING MAGNET
ANALYSING SLIT
SWITCHING MAGNET
TARGETS

FIG. 2. Schematic diagram of Tandem Electrostatic Accelerator.

PRINCIPLE OF THE TANDEM GENERATOR

Consider first the conventional van de Graaff generator illustrated in Fig. 1. Near the base of the machine, electric charge is sprayed on to a fast-moving rubberised belt. It is removed by means of a suitable collector in the top terminal, which therefore rises in potential. The voltage distribution between the top terminal and ground is controlled by a resistor chain whose individual components are attached to horizontal plates separated from one another by glass or porcelain insulators. The ions to be accelerated are generated by an electrical discharge in a small vessel in the high-voltage terminal and then enter the long evacuated tube which has as many electrodes as there are horizontal plates in the vertical column. The well-focused ion beam produced in this way is then brought into a horizontal plane by magnetic deflection and allowed to bombard a target of the element to be investigated.

The tandem generator (Fig. 2) differs from the orthodox machine just described in that the stack extends throughout the length of pressure vessel. The operation of the machine depends upon the voltage multiplication that can be achieved by starting with negative ions which are injected into the upper accelerating tube. The negative ions are accelerated towards the central high-voltage terminal of the machine and acquire an energy of perhaps 6 MeV. They then pass through a thin foil or through a tube containing gas at low pressure which, in the case of negative hydrogen ions, results in the removal of both electrons. The positive ions emerging from the stripper are then further accelerated in the second stage of the machine. Thus the tandem generator is able to produce particles with an energy of perhaps 10 MeV when the highest D.C. potential is only 5 MV.

The idea of using the principle of charge-changing to obtain voltage multiplication is due to W. H. Bennett of the U.S.A., who patented the idea about twenty-two years ago. His suggestion was revived by L. W. Alvarez of the University of California in 1951 and was taken up seriously by the High Voltage Engineering Corporation, also of the U.S.A., in 1955. This company has manufactured a horizontal tandem generator which came into operation in January of this year at the Chalk River Laboratory of Canada, following successful trials at the factory.

In 1956 interest in the tandem generator was growing in the Atomic Energy Authority because of the potentialities of the machine for nuclear research in those fields of interest to the Authority. Some consideration was given to the possibility of buying machines from America, but in view of the high cost in dollars, the early state of the development and other factors, it was decided to build two machines in this country, at AERE, Harwell, and AWRE, Aldermaston. The design and development work was shared between the two establishments, and the engineering work was carried out by Metropolitan-Vickers of

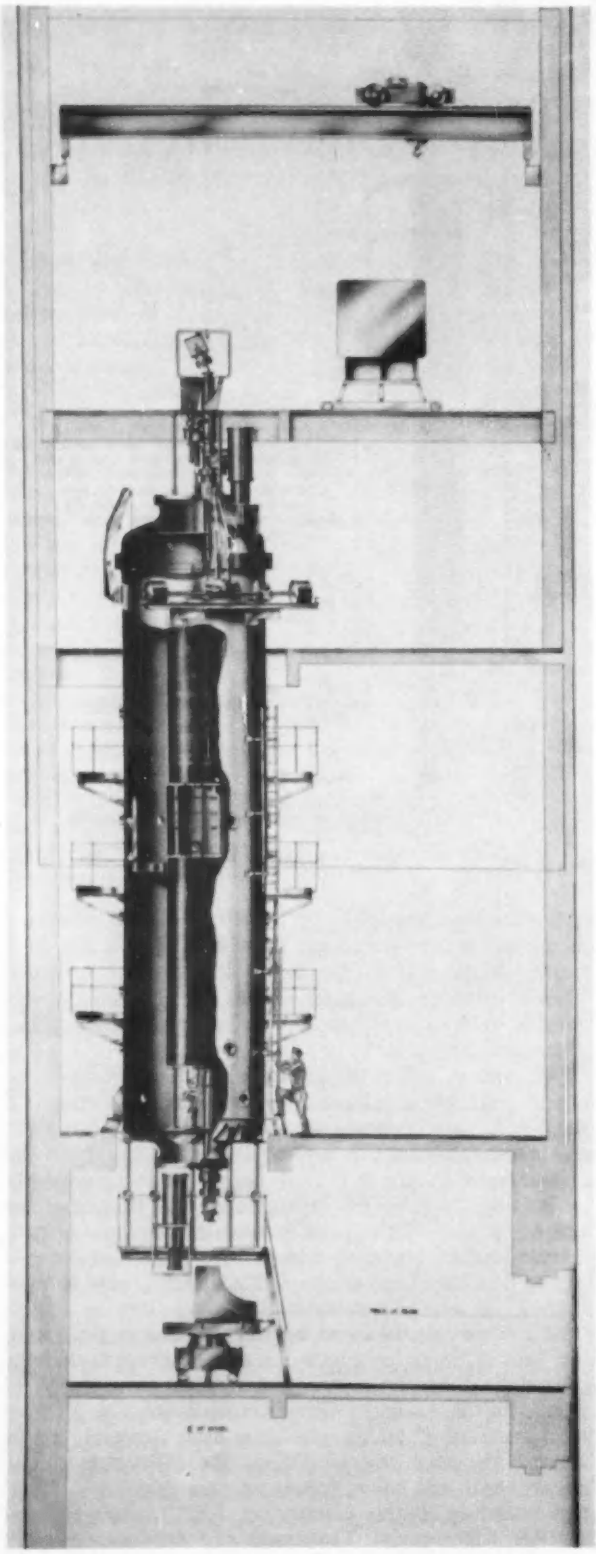


FIG. 3. Cut-away diagram of the Tandem Electrostatic Accelerator installed at Aldermaston.

Manchester. The machines are vertical and are enclosed in pressure vessels about 45 ft. long and 9 ft. in diameter filled with an insulating gas mixture to a pressure of about 200 lb./sq. in. Access to the machine for general servicing and maintenance is by manholes at the base, and a lift is provided with its driving mechanism situated outside the pressure vessel. In the Aldermaston machine the ion beam travels a total distance of about 100 ft. from ion source to target and must pass through the stripping tube in the high-voltage terminal which is 9/64 in. in diameter and 24 in. long. Thus alignment and focusing problems are severe.

Both machines began operation during March 1959 and initial performances are encouraging. At the time of writing, experiments have been carried out at Aldermaston with 11·5 MeV protons and deuterons, and beam currents up to 5 μA have been obtained on targets. There is little doubt that both voltage and current ratings will be further increased in the course of development and testing.

PROGRAMME OF RESEARCH

The aim of experimental work in the nuclear structure field is the provision of data which can be used to test nuclear models for a wide range of nuclei. Ultimately, it is hoped that it will be possible to describe the structure of complex nuclei in terms of the fundamental interactions between the neutrons and protons of which they are composed.

In recent years, some progress has been made along these lines, particularly for the lighter nuclei. For example, it is known that certain nuclear configurations are particularly stable; in this respect they are nuclear analogues of the closed electron shell configurations of the inert gases familiar in atomic physics. For those nuclei which consist of a closed shell with only two or three extra-core particles, detailed shell model calculations have been carried out and the results compared with experiments. The agreement is very satisfactory in certain cases, for example, F^{18}, which consists of an O^{16} "core" with a neutron and a proton in outer orbits. The energies and angular momenta associated with the first few excited states of F^{18} have been obtained through studies of the angular distributions of protons in the reaction $O^{16}(He^3,p)F^{18}$ and the assignments have been checked by studies of the γ-rays emitted as a result of transitions between the levels. It turns out that the experimental results are reasonably explained if it is assumed that the force between the extra-core nucleons in F^{18} is similar to the force acting between the neutron and proton in the deuteron, which is a very satisfactory conclusion.

For nuclei which have many particles outside closed shells, collective interactions between the particles play a dominant role in determining the energies and other properties of the low-lying excited states. Here again, a detailed theory exists and more experimental data are required to test its predictions, particularly for the heavier nuclei. It is for the investigation of these heavier nuclei that the tandem generator, with its higher energies, will be particularly valuable.

In order to make full use of the potentialities of the tandem generator, it is essential to have apparatus which can analyse the charged particle products of nuclear reactions with high precision. At Aldermaston we have

designed two large magnets for this purpose. The first of these instruments is known as a multi-channel broad range spectrograph. In its final form, the magnet and its exciting-coils will be contained in a vacuum chamber with the target at the centre. The bombarding beam reaches the target through a hole in the magnet yoke, and disintegration particles are analysed in the twenty-four gaps in the magnetic circuit. The particles are recorded in long strips of photographic emulsion which are mounted so as to receive the particles emerging from the gaps. These gaps are arranged in two banks, and cover the range 5° to 175°, so that in a single run it is possible to record both the energies and the intensity variation with angle of the particles arising from nuclear disintegrations. This type of apparatus is very economic in machine operating time, but the analysis of the photographic emulsions is at present a long and rather tedious task.

Another large magnet to be used in nuclear reaction studies is shown in Fig. 4. Here the particles are deflected through 180° in a specially shaped magnetic field designed to increase the collecting power while maintaining good resolution. The magnetically analysed particles are detected electrically by a scintillation counter so that time-correlated events such as the emission of γ-rays following particle emission may be recorded and studied. Thus we expect to record the energies of excited states of nuclei with high precision using the multi-channel spectrograph, while the detailed properties of some of the states will be further examined with the 180° magnet.

ADVANTAGES FOR NEUTRON PHYSICS

Van de Graaff generators are frequently used in nuclear physics laboratories as sources of neutrons, which are obtained by the bombardment of suitable targets with beams of protons and deuterons. The energy of the emitted neutrons can be varied by suitable choice of reaction and bombarding energy. Interest usually centres on the various interactions of the neutrons with other elements, such as elastic and inelastic scattering. These processes are of considerable interest in atomic energy programmes, and for this reason have been intensively studied.

As neutrons are uncharged, they are unaffected by electric and magnetic fields and their energies cannot therefore be measured by the familiar methods of charged particle spectroscopy. A method of measuring neutron energies which has gained favour in recent years is the time-of-flight technique. Here the *velocity* of the neutron is measured by timing its passage from source to detector with ultra-fast electronic equipment. In general, this method demands a pulsed neutron source which can be produced by modulation of the ion beam from the accelerator. If this is done by deflecting the full energy beam past a slit, neutrons will generally be produced where the beam strikes the defining apertures, and this gives rise to a troublesome background. The background can obviously be eliminated by pulsing the beam before acceleration, and here the tandem generator possesses the very considerable advantage that the ion source is located outside the pressure vessel, where it is readily accessible. It is this feature, combined with the ability to produce high energies, that makes the tandem such an attractive instrument for fast neutron physics.

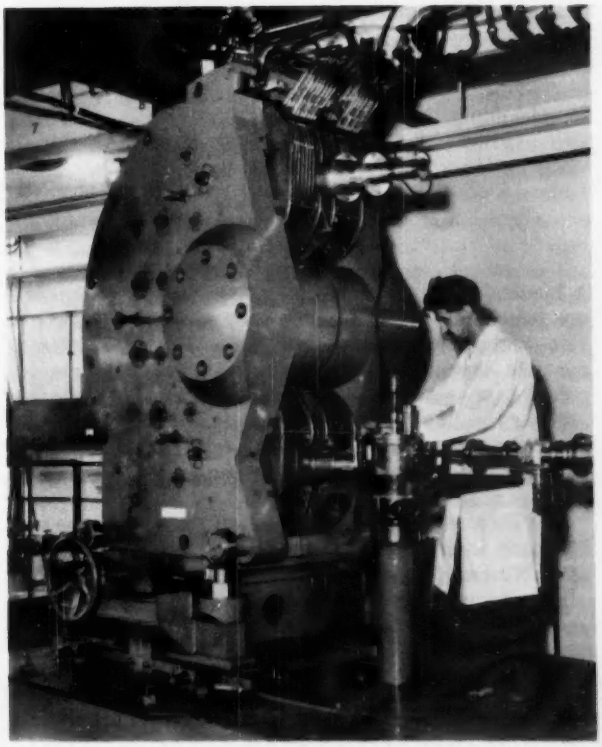
ACCELERATION OF HEAVY IONS

Another important application of the tandem generator arises out of the possibility of accelerating ions heavier than hydrogen or helium. In general, a heavy negative ion will lose several electrons in its passage through the stripper—for example, a 6 MeV negative oxygen ion may well emerge as O^{5+}. The resultant energy of the oxygen ion then becomes 36 MeV, and the nuclear reactions produced by such particles have some interesting features.

Heavy ions may also be used profitably to excite target nuclei by a process known as coulomb excitation, because the energy transfer occurs as a result of electrostatic, rather than nuclear, interaction. In coulomb excitation those nuclear states which arise as a result of collective motions of the nucleons are strongly excited; the availability of beams of high-energy heavy ions from the tandem generator will enable the search for these states to be extended to higher excitation. This will be a valuable method of checking the validity of the collective nuclear model.

The present tandem generator does not represent the final stage of development of the principle. A convenient method of extending the upper energy limit would be to inject high-energy negative ions, $\backsim$6 MeV, into a machine of the existing type. In this way it would be possible to produce proton and deuteron beams in the energy range 18 to 20 MeV with all the characteristic advantages associated with an electrostatic generator. Such a machine would be the ideal tool for nuclear structure research, for with it the properties of nuclei throughout the periodic table could be explored in detail.

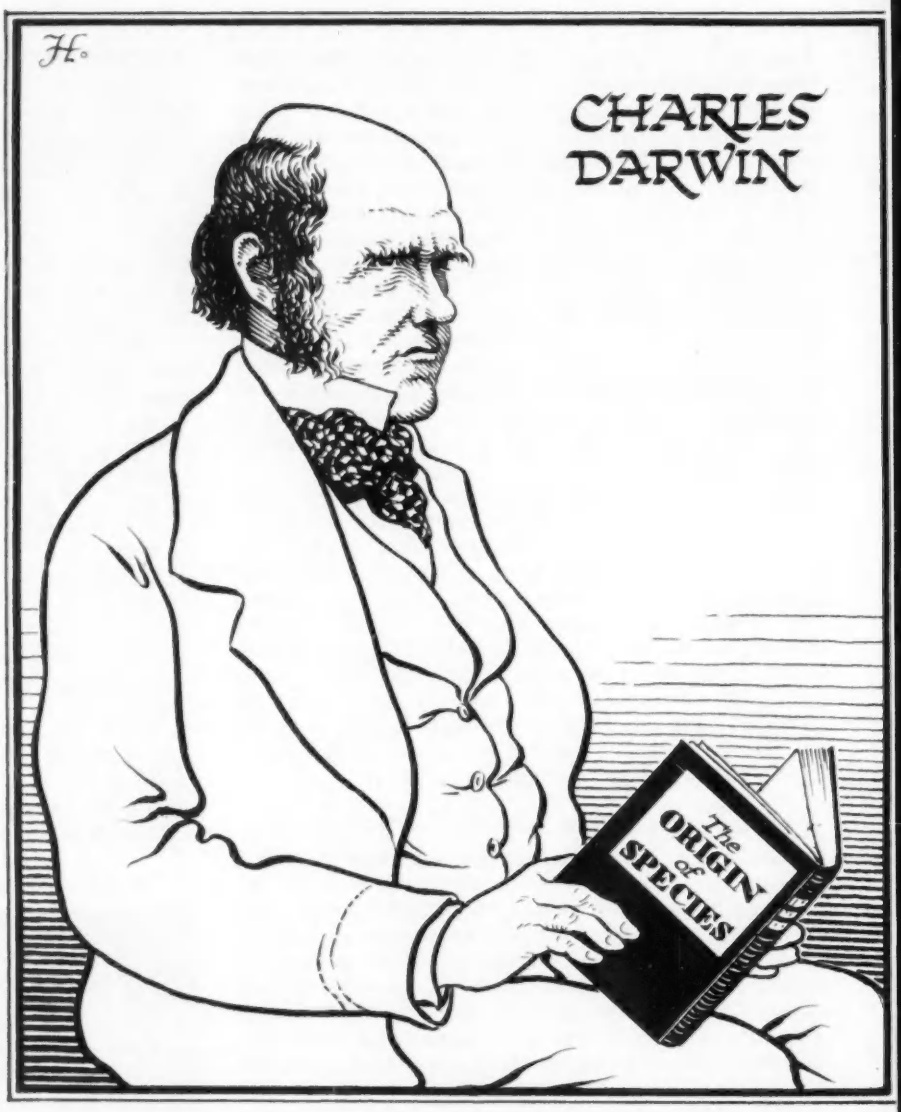
FIG. 4. Large magnet used to deflect particles through 180°.



DARWIN

WILLIAM E. DICK,
B.Sc., F.L.S.

In November 1859 "The Origin of Species" was published, and a revolution in modern thought was begun. Although most scientific texts are seriously out of date within ten years of their appearance, there are very few factual statements in Darwin's book which would not be acceptable today.



Specially drawn for DISCOVERY by Frank Horrabin.

A hundred years ago this winter "The Origin of Species" was published—one of the truly revolutionary events of the 19th century, which not only changed the direction of scientific thought but brought about great changes in political and economic philosophy and affected the religious beliefs of millions of men. (The full title of the book, it should be noted, was: "On the Origin of Species by Means of Natural Selection, or The Preservation of Favoured Races in the Struggle for Life".)

The book was expensive—copies of the first edition cost 14*s*. each when they were put on sale on November 24, 1859. Nevertheless, they sold like hot cakes, and that first edition disappeared on the day of publication. Within ten years another four editions were produced, and the final edition—the sixth—came out in 1872; although Darwin lived a further ten years after that date, he made no further revisions of the text. It has been translated into a great many languages, and it is my strong belief that if its total sales in all countries could be estimated it could be established that the book has been the scientific best-seller of all time. It has stood the passage of time as few other scientific works have done, a point that is particularly striking in these days when almost all scientific books are seriously out of date within ten years of publication. I agree entirely with the remark of the late Sir Arthur Keith that any omniscient biologist called upon to re-edit this classic work today would find that "scarcely a single fact would have to be withdrawn—so accurate was Darwin in making his observations and so careful was he in the selection of his authorities". That there continues to be a big demand for "The Origin of Species" was clearly demonstrated just after the last war when two British publishers—respectively Watts, and Oxford University Press—reprinted the *first* edition and the *sixth* edition within a year of each other. (The reprinted first edition is especially interesting for the brilliant preface by Prof. C. D. Darlington.)

FROM PARLIAMENT TO MUSIC HALL

It is very hard to exaggerate the impact which Darwin's book has had. When it first appeared it was bought and/or read by everyone who took a pride in being well informed; though designed by its author to convince other scientists of the reality of his theory of evolution, it was read by statesmen and politicians, bankers and engineers, industrialists and theologians, poets, philosophers. As Prof. Darlington has said (in the preface just referred to):

> ". . . all educated men felt it their duty to express an opinion on the problems discussed by Darwin. From Moscow and Munich to the frontiers of the New World, changing its shape as it moved, his doctrine quickly became known as Darwinism—a name to be pronounced with veneration on one side, and on the other with hatred or contempt. . . ."

It is remarkable how completely Darwin's ideas have been digested and absorbed; they have been accepted into everyday thought in a way that few scientific ideas have been. What other scientific theories have inspired a music-hall ditty such as the following:

> "Is it true that we all come from monkeys?
> When I look at you,
> I know it must be so."

The word "evolution" is now a part of common language; time and time again one comes across a passage referring to the gradual development of, say, laws, artillery, ships, cars, bicycles, atomic bombs, and one gets a phrase about "Model B evolving from Model A", which contains the basic concept of transformism, as Darwin put it forward so clearly. The theory of natural selection is now part of our common heritage and of the way we think. Darwin's concept of "sexual selection" is also very familiar today. Looking at p. 36 of the Penguin edition of "Room at the Top", John Braine's novel, one comes across "a grading scheme for women" which is an intriguing compound of the idea of sexual selection with natural selection operating according to a salary scale.

With this single book Darwin won immortal fame; his name has become part of Britain's glory along with that of Newton and Shakespeare. A modest man, Darwin himself was more than surprised by the success of "The Origin". The writing of it had been a painful process; not only was he a very sick man, easily exhausted by the intense effort of putting down on paper the concentrated ideas which had been fermenting in his brain for twenty years, he was also one who had always found writing a painful process, for he could not write fluently and only attained the great lucidity and coherence which characterises his prose by polishing and repolishing. When he finished "The Origin" he was literally worn out.

THE BORN NATURALIST

What manner of man was this retiring and always ailing naturalist who started a great renaissance in biology, a renaissance which influenced men's thinking well outside the confines of science?

Dr Erasmus Darwin (1731–1802) was his grandfather. As a physician, he built up a rich practice in Lichfield, devoting his leisure to the writing of poetry and to science. He was a keen member of the famous Lunar Society, which brought together industrialists like Josiah Wedgwood, (the great potter and a very dear friend of Erasmus), Matthew Boulton, Samuel Galton, and a number of men of science—including Priestley (discoverer of oxygen), James Keir, and Dr Withering; another regular "Lunatic" was Boulton's partner, James Watt. As a doctor, Erasmus was as brilliantly successful as he was unconventional in his prescriptions; had he wished, he could have been physician to George III. As it was, the rich of London had to travel to Lichfield if they wanted to consult him. His poems were very popular and very profitable; today we should regard his verses as somewhat lacking in human interest and poetry, but such contemporaries as Horace Walpole and William Cowper thought them extremely good. In one of the poems—"Zoonomia, or the Laws of Organic Life"—he put forward his ideas on evolution. Translated into Italian, it "was honoured by the Pope by being placed in the 'Index Expurgatorius'." Erasmus's views on the nature and causes of evolution had much in common with those of Lamarck. We know that Charles Darwin read "Zoonomia"; in his autobiography there is this telling comment:

> "I had . . . read the 'Zoonomia', in which [views similar to Lamarck's] are maintained, but without producing any effect. . . . I admired greatly the 'Zoonomia' (at the first reading): but on reading it a second time, after an interval of ten or fifteen years, I was much disappointed; the proportion of speculation being so large to the facts given."

Charles Darwin's father was Robert Darwin, the third son of Erasmus. We know that Robert was an extremely sensitive person, who became a fine physician in spite of the fact that he hated his profession because it constantly brought suffering before his eyes. He built up a large and prosperous practice at Shrewsbury, where Charles was born on February 12, 1809. His mother—Susannah, the daughter of Josiah Wedgwood—died when he was only eight years old, and Darwin recorded that he could "remember hardly anything about her except her deathbed, her black velvet gown, and her curiously constructed work-table".

Before the lad went to school at the age of eight, he had already acquired a taste for natural history and for collecting. Like young Carl Linnaeus, he was an omnivorous collector, being interested in plants, shells, seals, franks, coins, and minerals. Darwin considered that this "passion for collecting, which leads a man to be a systematic naturalist, a virtuoso, or a miser . . . was clearly innate, as none of my sisters or brothers ever had this taste". Darwin's greatest passion was for collecting beetles—by a curious coincidence, the same family which specially aroused Linnaeus's collecting instinct.

"A DISGRACE TO YOUR FAMILY"

School at Shrewsbury he found dull in the extreme: "the school as a means of education to me was simply a blank", he wrote later. He was not miserable at school—"I had many friends amongst the schoolboys, whom I loved dearly": he was simply bored stiff. The lessons failed to

arouse or satisfy his natural curiosity. In those days he was much more interested in adding to his various collections than in learning Virgil and Homer by heart, in shooting birds than in memorising details of ancient history and geography. His father was so discouraged by his school reports that he once was driven to rebuking Charles in these words: "You care for nothing but shooting, dogs, and rat-catching, and you will be a disgrace to yourself and all your family."

It should be recorded that, although the boy was taught no science at school, he and his brother had a fair laboratory in the garden tool-shed at home, where they carried out chemical experiments. Darwin said that "this was the best part of my education" in his schooldays, "for it showed me practically the meaning of experimental science". Their hobby earned Charles the nickname of "Gas" among his schoolfellows, and one public rebuke from the headmaster, who regarded chemistry as a useless subject and a waste of time.

Realising that Charles was gaining practically nothing from his school lessons, his father sent him to Edinburgh University. Charles was then sixteen and a half years of age. He was following in the footsteps of his father and his grandfather, who had both studied medicine at Edinburgh. During his two years at the Scottish university he never settled down to his medical studies. Probably the main reason for this was that he had already realised that he was bound to be left comfortably off when his father died, and that knowledge seems to have killed his incentive to concentrate on the syllabus. The medical course he found extremely dull; unfortunately, this applied with particular force to the anatomy lectures, and the result was that he never acquired the knack of dissecting properly—a practice which, as he himself said, "would have been invaluable for all my future work. . . . This has been an irremediable evil, as well as my incapacity to draw"—another skill which biologists need to have. He recalls two major operations which he witnessed as a student:

> "I rushed away before they were completed. Nor did I ever attend again, for hardly any inducement would have been strong enough to make me do so; this being long before the blessed days of chloroform. The two cases fairly haunted me for many a long year."

He did, however, acquire a great deal of zoological knowledge during his two years in Scotland, and early in 1826 he published his first zoological discovery—at the age of seventeen. In his holidays he spent much of his time shooting: "I think I must have been half-consciously ashamed for my zeal, for I tried to persuade myself that shooting was almost an intellectual enjoyment", because it required so much skill. There is no doubt that he was a crack shot; during his visit to South America, it is recorded that on one occasion he shot twenty-three snipe with twenty-four shots. (He took a typically modest view of this exploit, explaining that South American snipe were not so wild as English.)

After two sessions at Edinburgh, it was evident that a medical career would not be to Charles's liking. His father did not press him to stay there, even though he himself had carved out a successful medical career in spite of the fact that the sight of human suffering made him feel sick. Actually, his father was convinced Charles would have made a good physician; as Charles Darwin recorded in his autobiography:

> "My father, who was by far the best judge of character whom I ever knew, declared that I should make a successful physician—meaning by this one who would get many patients. He maintained that the chief element of success was exciting confidence; but what he saw in me which convinced him that I should create confidence I know not."

THE FRUITFUL YEARS

The upshot of their discussion at this juncture was Charles Darwin's departure for Cambridge University, with the object of qualifying for the clergy. Darwin stated that "I had scruples about declaring my belief in all the dogmas of the Church of England; though otherwise I liked the thought of being a country clergyman." Later in life he commented on the ferocity with which he had been attacked by the orthodox believers, adding, "it seems ludicrous that I once intended to be a clergyman".

Darwin did not find the courses at Cambridge much more interesting than those at Edinburgh. "During the three years which I spent at Cambridge my time was wasted, as far as the academical studies were concerned, as completely as at Edinburgh and at school", he said. According to his autobiography, he "got into a sporting set, including some dissipated, low-minded young men", and spent too much time drinking and playing cards. But there is reason to think that he was inclined to exaggerate the bacchanalian nature of the parties he described. One of the most revealing things he ever said about his days at Cambridge is this: "No pursuit was followed with nearly so much eagerness or gave me so much pleasure as collecting beetles." He went so far as to hire a labourer to scrape moss off old trees and to collect rubbish from the bottom of barges that had carried reeds from the fens, and from such material he collected some very rare kinds of beetle. In those days a close friend was his second cousin, W. Darwin Fox, an equally keen entomologist. Several of his fellow beetle-collectors became famous, and Darwin said: "It seems that a taste for collecting beetles is some indication of future success in life."

The luckiest thing that happened to him during his three years at Cambridge was his friendship with Prof. Henslow, a most versatile naturalist, who was professor of botany. So close was their friendship that Darwin came to be called "the man who walks with Henslow", and to Darwin their intimacy "was an inestimable benefit". Through Henslow he got to know the famous Dr Whewell, whom Faraday consulted when he needed to coin new technical terms made necessary by his discoveries and who added to the English language such words as *electrolysis*, *anion*, and *kation*. Darwin was always extremely modest about his accomplishments, and quite underestimated the worth of his collecting activities and natural history work at Cambridge; nearer the mark was the judgment of one of his sporting friends, who remarked of his work on beetles that he would some day be made Fellow of the Royal Society—"The notion seemed to me to be preposterous", noted Darwin.

It was Henslow who recommended Darwin for the

vacancy as unpaid naturalist on the voyage of the *Beagle*. This was a period when the Admiralty made a point of getting a good naturalist to accompany all its major exploring expeditions. The object of the *Beagle*'s voyage, under Captain Fitz-Roy, was to survey Patagonia, Tierra del Fuego, the shores of Chile and Peru, and some islands in the Pacific. This article is not the place to detail Darwin's experiences during the voyage, which lasted from Christmas 1831 until October 1836: anyone interested can find a full and engrossing account in Darwin's book, "A Naturalist's Voyage Round the World" (1845).

During those five years Darwin worked like a beaver, collecting, cataloguing and preserving specimens, and recording his observations on all kinds of natural phenomena. To the geological material, including a great many fossils, he gave particular attention. His inspiration in that direction was provided by Lyell's book, "Principles of Geology", which had just been published. This wonderful book was his "bible" during the voyage, and it is pleasant to record that many of Darwin's observations were incorporated into later editions of the book. "Principles of Geology" was the masterpiece of Sir Charles Lyell (1797–1875), a Scotsman who became geology professor at King's College, London, and it bred in Darwin a tremendous passion for geology. The friendship that developed later between Darwin and Lyell is one of the finest ever recorded in the annals of science.

To Darwin, Lyell always remained "the dear old master", whom he consulted continually. Lyell was a fervent admirer of all Darwin's works; it has been said that "a stranger who conversed with Lyell would have thought that he was the junior and a disciple; so profound was his reverence for the genius of Darwin". Those were the great days when science was still not professionalised; the friendships that existed between our great men of science were unmarred by the intense competition which is an inevitable accompaniment of extreme professionalisation and specialisation. (There is the wonderful example of Lyell and Huxley; Huxley visited the dying Lyell, fresh from delivering a lecture at the Royal Institution, and another scientist has recorded "the glow of gratitude which lighted up the noble features as with trembling lips [Lyell] told me how Huxley had repeated his whole Royal Institution lecture at his bedside".)

"THE ORIGIN OF SPECIES"

It is worth recording very briefly the things that particularly impressed Darwin during the voyage, for they were to have a great influence on all his subsequent thinking. There were the coral reefs of the Pacific. The Admiralty needed accurate charts of these waters, and Captain Fitz-Roy made numerous soundings around many coral islands, providing data which Darwin was able to use to great advantage in his book, "The Structure and Distribution of Coral Reefs" (1842)—a most important work in which new theories of coral-reef formation were put forward. There were the fossils of South America, which he dug out laboriously from the red-clay earth of the Pampas. He realised that the fossilised bones, teeth, and scales which he collected belonged to extinct animals—such as *Megatherium*, *Mylodon*, and *Glyptodon*—which were quite distinct from, but of strikingly similar structure to, those now living in South America. He was also excited by the sight of the sloths, ant-eaters, and armadillos which were obviously so different from the edentates of Europe. From these observations Darwin drew the conclusion that faunas over geological ages were not transformed by "catastrophes" which wiped out one fauna, leaving a biological vacuum which a new and entirely different fauna would fill; he could see the "ghost-like" similarities between living species and extinct species. Somehow or other species must have the ability to change somewhat over the aeons of time.

Lastly, there were his observations of the plants and animals of the Galapagos Islands. This archipelago, consisting of a number of volcanic islands (one explorer has called them "the Enchanted Islands"), lies on the equator and is about 600 miles west of Peru. Beaches of snow-white sand alternate with pitch-black lava rocks which are spangled with scarlet crabs. One visitor has given this vivid description of these islands: "Here the Devil must have been making toffee for his offspring and allowed the pot to boil over." The region has been aptly described as "the dominion of reptiles", and Darwin remarked that the reptiles were the most peculiar feature of the islands' geology. He did not find many different species, but noticed that the numbers of individuals of each species were extraordinarily great. Outstanding were the giant tortoises which eat succulent cacti; these beasts could grow so huge as to require six to eight men to lift them up—200 lb. of meat could be cut from such specimens. Darwin had many a ride on these tortoises, though he "found it very difficult to keep my balance".

The extraordinary point, which he learnt from the Vice-Governor of the Galapagos, Mr Lawson, was that the giant tortoises from the different islands were markedly different; Mr Lawson could identify with certainty the island from which a particular tortoise came by examining its shell and body. Darwin concluded that these tortoises were aboriginal inhabitants of the archipelago; in the course of years several distinct species had come into existence on the different islands.

There are no native mammals on the Galapagos, and Darwin could see that the archipelago has remained in the same state which prevailed in the "Age of Reptiles"—the geologist's Mesozoic Period—before the mammals evolved. Protected by a water barrier, an almost extinct set of animals has been preserved through a period in which the mammals superseded the giant reptiles in most parts of the world.

Another group of animals which he studied were the finches; all of these are similar in form and plumage, and yet there are subtle distinctions between the species—the beaks differ quite considerably, and Darwin began to think of their being derived from a common ancestor but then becoming adapted to different feeding habits, so that one species has a beak like a hawfinch, another's resembles that of a starling, and a third's is somewhat parrot-shaped. As Darwin said of the Galapagos animals:

> "Each small island has its own 'fauna'—this being very strikingly shown in the case of the reptiles and birds. And yet, though the *species* were different, there was obviously a very wonderful 'family likeness' to one

another between the forms in the several islands and between them all and the animals living in the adjoining portion of the continent [of South America]. Surely this could not be accidental, but must indicate relationships due to descent from common ancestors!"

The notes and specimens which Darwin was sending back to England caused a considerable stir; for example, we find Prof. Sedgwick telling Darwin's father that his son should take a place among the leading scientific men. In particular, the experts were excited by the fossils which he had sent back to Prof. Henslow.

"DOING HIS BARNACLES"

The *Beagle* returned to Falmouth in October 1836. Darwin was soon at work preparing his "Journal of Travels", which he found easy to do, as he had kept a very comprehensive journal in manuscript throughout the voyage. We discover that in July 1837 he opened his first notebook for facts relating to the "Origin of Species".

In 1839 he married his cousin, Emma Wedgwood, granddaughter of Josiah Wedgwood. They set up their first home in London's Upper Gower Street. In 1842 they moved to Down, a quiet village near the Kent Weald, and in that year Darwin published his great work on coral reefs. At this point it is important to mention the fact that never again did he enjoy good health; as often happens with the constantly sick individual, he pressed forward with unrelenting concentration, quite possibly obsessed with the fact that there was so much he wanted to do and perhaps so little time in which to achieve all he desired. One of his closest friends said that he worked to a strict schedule, and that when the rigidly self-imposed task of each day was completed he found himself near to mental collapse. No wonder Darwin lost his taste for music and poetry, of which he had been passionately fond; the energy he had left was sufficient only for a nightly game of backgammon or light novel reading. Few men have ever driven themselves so hard as Darwin.

During these days he saw more of Sir Charles Lyell than any other scientist. Another close friend was the "prince of botanists", Robert Brown, discoverer of "Brownian movement". Among the men he met socially were Humboldt (the great German naturalist whose writings first gave Darwin the "travel bug"), Buckle, Macaulay, Lord Stanhope, Charles Babbage (the mathematician who invented mechanical computers), and Carlyle—of whom he said, "I never met a man with a mind so ill adapted for scientific research."

His next work was a new edition of "Journal of Researches" (1845), originally published in 1839 as part of Captain Fitz-Roy's account of the *Beagle* expedition. This work was his first love: "the success of this my first literary work always tickles my vanity more than that of any of my other books".

The year 1846 found him working on a huge book about barnacles. This was to take him eight years to complete; so much did he concentrate on it that one of his children, so used to being told that Daddy was "working on barnacles" and must not be disturbed, was driven to inquire —about a visitor who was staying at Down House—"When does Mr X do his barnacles?"

THE LETTER FROM WALLACE

With his grand opus on barnacles out of the way, Darwin got down to the task of arranging his huge pile of notes, of observing and of experimenting on matters relevant to what he called "the transmutation of species". The date was September 1854. Long before that time he had already had his inspiration about the mechanism of "natural selection". The direct source of that inspiration was Malthus's "Essay on the Principle of Population as it affects the future Improvement of Society", which, he says, he "happened to read for amusement". The Reverend T. R. Malthus (1766–1834) first published that essay in 1798, and greatly enlarged it in 1803. The principal idea in it was a simple one: that while population increases roughly in a geometrical ratio, the means of subsistence—that is, food supplies—increases only in an arithmetical ratio. (It is an almost incredible coincidence that exactly the same inspiration was to come to Alfred Russel Wallace, just after reading the Malthus essay, and while his brain was seething with feverish ideas triggered off by a bout of malaria—Wallace was then on a collecting expedition in Ternate, in the Malay Archipelago.)

Another brilliant idea came to Darwin in 1842. He had posed himself this question: what is the reason for the tendency of organic beings descended from the same stock to diverge in character as they become modified? Darwin recorded that he could "remember the very spot in the road (near Down House), whilst in my carriage, when to my joy the solution occurred to me". The solution, he said, is that the modified offspring of all dominant and increasing forms tend to become adapted to many and highly diversified places in the economy of nature. A good example is provided by the evolution of reptiles, which in the Mesozoic Period diverged to such an extent that—starting as terrestrial animals—they invaded the oceans, rivers, and lakes, and also the air. The same tremendous divergence occurred later when the mammals evolved and drove the giant reptiles into extinction, so savage and total was the competition between the biologically more efficient mammals and the reptiles.

Darwin produced a sketch of his great evolutionary theory in 1844. This was not intended for publication, however, though he did provide in his will for its posthumous editing ("Lyell would be the best [editor], if he would undertake it") and printing. The completion of this sketch, a document of 230 pages, prompted him to tell his wife: "If, as I believe, my theory in time be accepted, even by one competent judge, it will be a considerable step in science." The next decade he spent accumulating further facts in support of his theory. His friends—in particular Lyell and Dr Joseph Hooker of Kew Gardens—kept pressing him to publish his theory, and eventually, in 1856, he started a book which he planned to consist of at least three volumes. It was while he was involved in this colossal effort that a letter was delivered at Down House—in June 1858—which turned his plans upside down. This was the famous letter from Wallace setting out his own ideas about evolution—the ideas which emerged from the maze of cerebration brought about by malaria and Malthus. Before replying to the letter, Darwin decided to consult Lyell. He sent him the letter and a covering note in which he commented:

"I never saw a more striking coincidence; if Wallace had my manuscript sketch written out in 1842, he could not have made a better short abstract! Even his terms now stand as heads of my chapters. . . . So all my originality . . . will be smashed, though my book, if it ever had any value, will not be deteriorated."

A NOBLE SOLUTION

At this "bolt from the blue" he was quite prepared to sacrifice his own theory and give all credit to Wallace for first publication. As Sir Arthur Keith has put it:

"Abraham with his knife and bundle of faggots was resolved to make the supreme sacrifice, and so was Darwin, and he would have done it had not his friend Lyell intervened."

He counselled a different course; and the judgment exercised was indeed worthy of Solomon. Justice was done exactly in the way he recommended: on July 1, 1858, a summary of Darwin's theory and Wallace's letter were presented to the scientific world at a meeting of the Linnean Society of London. Curiously, their conjoint communication caused no great stir; the probable explanation is that the intellectual "soil" was not quite warm enough to allow the seed of a revolutionary new theory to germinate. The behaviour of Darwin and Wallace faced with so extraordinary a situation makes the incident one of the most remarkable in the history of science; "never was there such a noble example of personal abnegation", and it reflects everlasting credit on the two main figures and upon Lyell and Hooker.

His friends realised that Darwin's plans for a huge three-volume work must now be scrapped. What was required without delay was something far less ambitious. So it was that Darwin sat down and started on "Origin of Species" within three weeks of that epoch-making meeting of the Linnean Society. His aim was a book of 500 pages, about the same size as Lyell's classic textbook on geological principles. The manuscript was finished in May 1859. Few books of such a size and of such importance have ever been written so rapidly. His intense effort left Darwin completely exhausted, and we know that his health broke down so completely that he had to retire to Dr Lane's hydropathic establishment at Moor Park. Darwin's verdict on his script was modest in the extreme: "I have tried my best to make it clear and striking, but very much fear that I have failed; so many discussions are and must be very perplexing. *I have done my best.*"

The verdict of history is that his best was very good indeed; of all judgments Darwin would probably have been most proud, had he lived to read it, of the verdict given by a literary man, Prof. George Sampson, in "The Concise Cambridge History of English Literature":

"Darwin was a modest man and did not suppose that he had said the last word about the origin of species; but in his simple and almost religious way he said a first word of such power that the year 1859 still marks an epoch in the history of thought. [This book] changed the intellectual outlook of the world."

GIANT MAGNET

An electromagnet ring is being built by Joseph Sankey & Sons, Ltd, for the National Institute for Research in Nuclear Science. The magnet will be part of a 7 GeV proton synchrotron—a 7000 million electron-volt "atom smasher" —at the Rutherford High Energy Laboratory, Harwell. When finished, the synchrotron is to be used for proton experiments not only by Harwell, but by universities and institutions which have neither the money nor facilities to build such a machine.

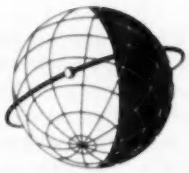
The magnet will weigh 7000 tons and be 160 ft. in diameter when finished. It is composed of 336 sectors of 20 tons each; each sector consists of 45 silicon steel plates, completely insulated from the next by a special coating, and tapered to half a degree at the rear to ensure a perfect fit with the next.

The temperature for each sector must remain constant to within 0·75°C during the final machining. Any variation from this temperature would cause the machined surfaces to be inexact. The slightest error is serious as the throat of the C-shaped magnet has to be accurate to 0·005 in. and both faces to no more than 0·004 in. out-of-parallel to each other.

The accuracy is necessary as the throat of the magnet carries a vacuum tube through which the proton beams will be accelerated to a velocity of just under the speed of light. The protons will be injected into the 7000-ton magnet ring from a subsidiary accelerator of 15 million volts and accelerated for 0·7 sec. During that time they will have travelled round the magnetic ring a distance equal to nearly four times round the world. On reaching maximum velocity the protons are "shot" at a target and the behaviour of secondary particles resulting from collisions between the bombarding particles and nuclei in the target material is studied. Any bombarding particles that miss the target will enter a specially built earth wall 20 ft. high topped by 6 ft. of concrete. Hence radiation hazards will be negligible.

The only other really large synchrotron in Europe is the CERN 600 MeV synchro-cyclotron which is also working with elementary particles (DISCOVERY 1957, vol. 18, No. 11, p. 460; and 1959, vol. 20, No. 2, p. 53). However, the work on the two synchrotrons will not overlap; they will, in fact, be complementary to each other as the CERN synchrotron is concerned with high velocity whereas Harwell will be concerned with high intensity.

GEOPHYSICS AND SPACE RESEARCH



By ANGELA CROOME

International Space Co-operation

The Russians made a most important proposal on October 6 at the annual session of the United Nations General Assembly. This was for an international conference to pool experience on the exploration of outer space, to be held under UN auspices. The proposal was made by the Soviet Deputy Foreign Minister, Mr Kuznetsov. It was promptly and warmly welcomed by the U.S. delegate to the UN, Mr H. Cabot Lodge.

This proposal and the quarter from which it comes is especially welcome at this time. Official scientific relations between the leading nations engaged on space research had reached something of an impasse, preceding this development. The Russians have refused to take part in the UN committee on outer space because of the constitution of this body, which they considered gave them insufficient representation. The Russian delegation recently withdrew from COSPAR for similar reasons. At the time of the Soviet proposal at the United Nations Assembly it was not clear whether COSPAR'S parent body, ICSU, would succeed in revising the COSPAR constitution in such a way as to meet the Soviet difficulties. The welcome election of Academician Leonid Sedov to the presidency of the International Astronautical Federation in September was no doubt a straw in the wind, though it must be doubted whether the IAF has sufficient standing to fulfil Russian ambitions of gaining a clear voice in joint international space research deliberations.

Appeal for *Vanguard III* Records

The U.S. National Aeronautics and Space Administration have made a general appeal for records of the initial transits of the 50-lb. *Vanguard III* which was successfully launched from Cape Canaveral on September 18. Apparently this was instrumented with a duplicated package of the apparatus designed for the *Vanguard* that failed at take-off at the end of July. *Vanguard III* is measuring solar x-rays, geomagnetism, and other environmental parameters at the edge of space. This is understood to be the last *Vanguard* that will be launched.

Lunik III

Lunik III, combined lunar probe and long-period earth-satellite, was launched on October 4, two years almost to the hour of the launching of *Sputnik I* and the opening of the "space age". The tremendously confident Soviet predictions of the orbit and radio behaviour of *Lunik III* were as impressive as the engineering feat itself. *Lunik III* is understood to have relied on very high precision launching and not on "in-flight" guidance for its amazingly accurate achievement. Main object: to photograph the far side of the Moon. Solar cells and ground-command instrument control incorporated. Predicted lifetime: indefinitely. Predicted successor: a soft landing of instrument package on the Moon and establishment of permanent Earth–Moon radio link.

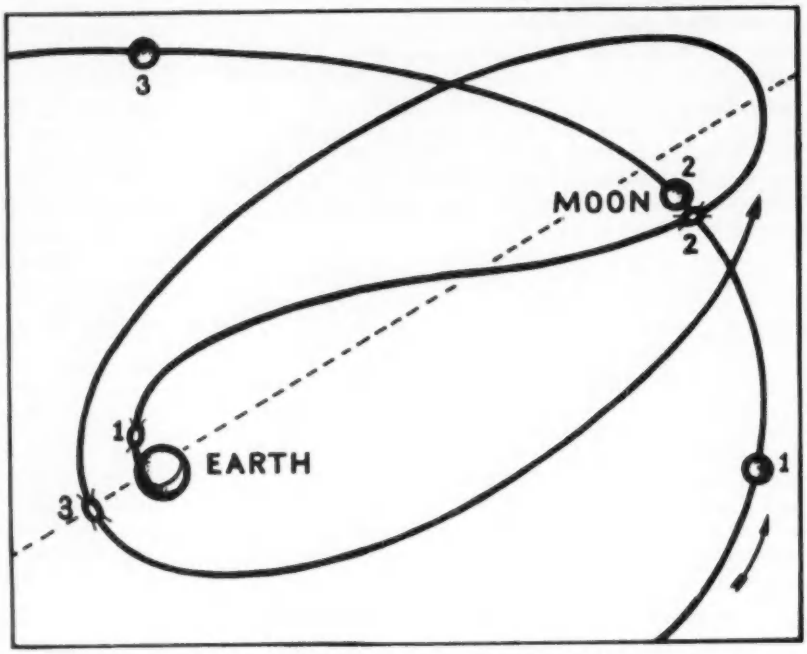


FIG. 1. Diagram of the movement of *Lunik III* issued by *Tass* on October 6. (1) is the position of the Moon and the rocket at launching; (2) the position of the Moon and the rocket at the moment of closest approach; and (3) the moon and rocket positions as the latter returns towards the Earth.

Initial Results from *Lunik II*

Lunik II, the second Soviet space-probe, made the first contact yet achieved with another heavenly body, by impacting the Moon close to the centre of its earthward face at 2 minutes past 10 p.m. on September 13 BST (2 minutes, 24 seconds past midnight, September 14, Moscow time). The event was "witnessed" by a huge British audience, those who were tuned into a BBC "live" broadcast from Jodrell Bank radio research station and noted the abrupt cessation of the *Lunik*'s radio signal that was being tracked by the 250-ft. radio telescope.

There have been some reports of visual observation of the impact from various foreign observatories and two British observers, but these are less convincing. Observers at the Budapest Institute of Astronomy, using 18-cm. and 30-cm. telescopes, reported a small dark ring at the moment of impact. This rapidly increased in diameter, "becoming paler as it grew and quickly dissipating as a small grey blob." This ring was noted by one research worker, who quickly called four others, including the observatory's director, all of whom confirm the finding. They presume that the impact threw up a cloud of dust from the Moon's surface, and this is what they saw.

If this visual observation can be confirmed, it provides evidence to settle the controversy over the composition of the Moon's surface. At a recent technical panel meeting of American scientists engaged in planning the instrumentation for the future U.S. lunar probe pro-

FIGS. 2, 3, and 4. *Lunik III*, which on September 13 reached the Moon, carried apparatus to produce a luminescent sodium cloud during flight on the night of September 12 for accurately positioning the rocket. (*Left*) FIG. 2. The preliminary phase of the artificial sodium cloud. (*Right*) FIG. 3. The artificial sodium cloud at maximum brightness.

gramme, the proceedings were brought to a standstill because there could be no agreement among the experts as to what sort of "soft landing" should be prepared for—was the vehicle to be able to operate successfully in deep dust-dunes? or on volcanic rock of the pumice variety? or on very hard and glassy basaltic material? There is some chance that photographic information of the far side of the Moon expected from the Russians' *Lunik III* launched in October may provide some evidence on this vital question.

The rocket impacted the Moon somewhat to the east of the Mare Serenitatis and close to the craters Aristylus, Archimedes, and Autolycus at an angle of 60° and at a speed of 7200 m.p.h. (both in relation to the Moon's surface), according to a *Tass* announcement on September 21. The statement continues: "The distance from the instrumented container's point of impact with the Moon to the centre of the visible surface is in the region of 800 km. (about 500 miles). Interpretation of the information obtained shows that the final stage of the rocket also reached the surface of the Moon." The impacting objects were sterilised to prevent any terrestrial contamination of the Moon that might confuse later biological or radiation studies.

The container was equipped to scatter light metal plaques impressed with the insignia of the U.S.S.R., upon the Moon's surface in the vicinity of impact. It is also understood that the container contained an "indestructible capsule" carrying a copy of the Soviet national anthem and a Soviet flag. The Soviet Union has, however made an official statement that they have no territorial pretensions to the Moon and will make no national claims of this kind.

This *Tass* statement lists the preliminary data obtained by *Lunik II*'s instruments, all of which are said to have functioned as planned, as did the telemetry equipment, throughout the flight. The greatest interest attaches to this, the first direct measurements of the lunar environment. This prompt publication of the preliminary analysis of data is greatly to be welcomed, and we print the *Tass* statement on this material verbatim.

1. **Lunar magnetism:** "No magnetic field has been detected in the vicinity of the Moon, according to the readings of the magnetometer within the limits of its sensitivity and deviation error (of the order of 60 gammas)."
2. **Radiation belts:** "The measurements of the intensity of radiation in the vicinity of the Moon did not reveal any radiation belt of charged particles, this being in agreement with the result of magnetic measurements. Measurements were carried out within the Earth's radiation belt."
3. **Cosmic and other radiation:** "Measurements of the total flux of cosmic radiation and the streams of helium nuclei (α-particles) and carbon, nitrogen, oxygen, and still heavier nuclei forming part of the cosmic rays were made all along the path of the rocket's flight through outer space. Additional information was obtained on X-rays, γ-rays, electrons of high and low energies, and high-energy particles."
4. **Discovery of a "lunar ionosphere":** "A recording was made of currents generated by particles of ionised gas which penetrated from the surrounding medium into the four traps for positively charged particles installed in the container. The magnitudes of the recorded currents vary along the path of the rocket's flight; tentative estimates indicate that in some regions between the Earth and the Moon the concentration of ionised particles is below 100 per c.c. The recorded currents increase within something in the region of 10,000 km. (about 6200 miles) of the Moon. This can be accounted for either by the Moon being enveloped in a blanket of ionised gases—a kind of lunar ionosphere—or by the Moon being surrounded by a region in which there is an increased concentration of corpuscles with energies of the order of dozens of volts."
5. **Lunar impact position:** "The selenographic latitude of the point of impact on the lunar surface is so far estimated at plus 30° and the selenographic longitude at zero."

This calculation is derived from analysis of the actual flight path of *Lunik II* based on recorded data obtained from measurements and observations of all kinds (see Figs. above). The published radio frequencies, which were received with good signal strength by Jodrell Bank, were at 19·993 Mc/s and 183·6 Mc/s.

Peaks and Pockets in Radiation Belt

Preliminary results of measurements being made by the American "paddlewheel" satellite (*Explorer VI*) were made available at the very end of September. It was launched on August 7 into a highly elliptical orbit with a period of 12 hours —though this achievement has been dwarfed by the Soviet success with *Lunik III*, in doing this on an enormously grander scale, with the added complication of making a close approach to the Moon on the way. (Estimated apogee of *Lunik III*, 300,000 miles; period, 14 days.)

The American paddlewheel satellite's findings appear to throw the Van Allen radiation picture once more into confusion. Instead of the comparatively neat pattern that was beginning to emerge as a result of the flights of the two *Pioneer* space probes (*III* and *IV*) and *Sputnik III*'s long-continued measurements (see these Notes for May 1959), the suggestion is that there are *three* Van Allen belts. Alternatively, one may consider that there is one deep region of radiation of the

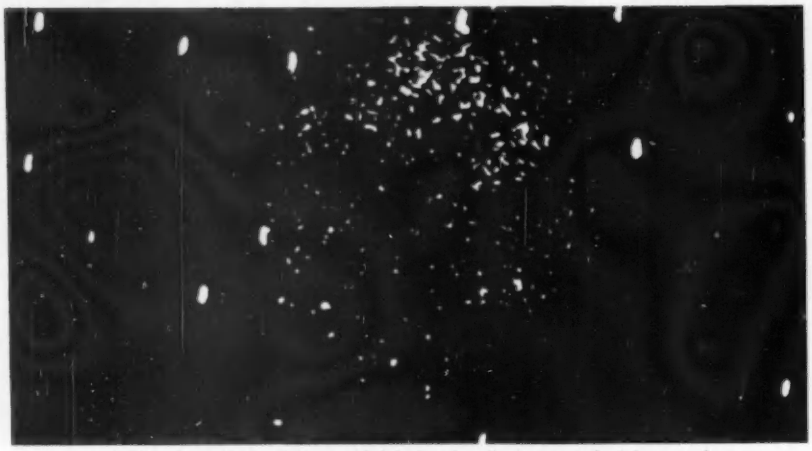


FIG. 4. The last phase of the artificial cloud—all photographed by members of the Astrophysical Institute of the Kazakh Academy of Sciences.

order of many thousands of miles thick with at least three distinct peaks of considerably high intensity with troughs of lower intensity lying between, the whole having a greater flux of radiation than in the regions of cis-lunar space beyond. The new data indicate that peak intensities in this region lie at 2500 miles above the equator, at 10,000 miles above the equator, and—this is the main contribution of the "paddlewheel" data so far—1200 miles up, this last and nearest peak being about 300 miles thick. Prof. John Simpson of Chicago University, who has instrumented the experiment, describes this as the "proton belt". The material of this lower "belt within a belt" is thus different in kind, charge, and electrical sign from that detected farther out. The "paddlewheel" has also revealed the existence of temporary pockets of high-intensity radiation which are associated with the ejection of high-energy electrons from the Sun.

Freden and White of the University of California have identified protons of 700 MeV as the components of the lower fringes of the Van Allen belt. An emulsion stack was recovered from a 500–600-mile-high rocket flight this summer. No α-particles or electrons were observed.

British Naked-eye View of U.S. Satellite

During the first week of October it was possible to see *Discoverer VI* with the naked eye in Britain. This was the first time that this had been possible with an American satellite. *Discoverer VI* came down during the second week of October. On three evenings it passed over with the brightness of the Pole Star and was visible with glasses on several other occasions. (None of those *Discoverers* that has achieved orbit has a long life as they are put into low orbits.) The *Discoverer* satellites, which are part of the U.S. Defence Department programme, are launched into 100-mile-high orbits that are only a few degrees off a pole-to-pole path. Their size and polar orbital path make them much the most promising American material for amateur visual observations from Britain so far. There is some hope that the "paddlewheel" may be visible when perigee precesses sufficiently to bring it over the northern hemisphere. Until the American plan to place an inflatable foil sphere, perhaps 100 ft. across, is successful, amateur Moon-watchers must be content with this—and with the Soviet space-vehicles, notably *Sputnik III*, not now expected down till January or February 1960.

SPACE CALENDAR

August 27: *Polaris* missile fired from submerged submarine for the first time.

September 9: *Mercury* prototype man-in-orbit capsule first launched into ballistic trajectory in *Atlas* nose-cone. Capsule test satisfactory; *Atlas* flight fell short.

September 15 and 16: *Jupiter* missiles fail to put 14 pregnant mice, frogs, and other biological specimens into space flight.

September 17: *X-15* experimental space aircraft makes successful powered flight from 38,000 ft.

September 17: *Transit 1* (ARPA) navigational satellite failed at launch from Cape Canaveral.

September 18: *Vanguard III* successfully launched.

September 24. "Project Farside" *Atlas-Able* rocket blew up at Cape Canaveral on ground-test. This Americal project to pass behind the Moon and photograph it, due for October, was consequently postponed.

Are Mars' Satellites Artificial?

Mars has two small satellites circling it, called Phobos and Deimos.

Are they artificial satellites placed in orbit by Martians some thousand million years ago? A group of Russian astronomers, headed by one of the most brilliant of the younger group, Dr I. Shklovsky of Leningrad, thinks they are. A paper on the subject was tabled by the Russians at the September meeting of the International Astronautical Federation but was squeezed out of the programme.

Shklovsky's view is based on several characteristics of Phobos and Deimos that sharply divide them off from all other natural satellites known. These same characteristics they share with artificial satellites. Thirteen artificial earth satellites have so far been launched and eight are still circling the globe at this moment. And there is the Moon.

Some new evidence and an intensive study of Mars satellites by the Russians indicates that Phobos is a hollow sphere ten miles across but with walls only 8 in. thick. This is very odd indeed and can only be explained by assuming that it was manufactured rather than evolved by the processes of nature. Phobos has been speeding up in its orbit in recent decades in a way that is incomprehensible if it was a solid body like other natural "moons". It appears, in fact, to be coming down in the manner we have become accustomed to from the ends of *Sputniks I* and *II*; the final plunge, however, may not occur for another fifteen million years. This is a mere "tick" of astronomical time!

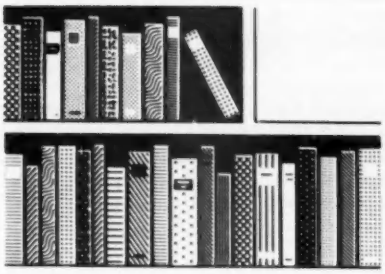
Several American scientists have endorsed Shklovsky's calculations. One of these is Prof. Fred Singer, a leading figure in international astronautics and the protagonist of the *Mouse* satellite idea that has had such a wide influence.

Another thing about Phobos and Deimos which is difficult to explain if they are moons, is why they are so small (comparatively), and why they circle so close to their planet.

Other puzzles remain. Supposing Phobos and Deimos are artificial satellites, who put them there? When? and why?

Shklovsky's idea is that a race of Martians now extinct launched them thousands of millions of years ago. Mars' atmosphere now is known to contain no oxygen, so that intelligent life as we know it on Earth is highly unlikely to exist there. There may be some mosses but not men. But many astronomers consider this has not always been so. Thousands of millions of years ago Mars probably had a breathable atmosphere and perhaps people breathing it. It will be some time before Shklovsky's thesis can be either conclusively proved or disproved.

THE BOOKSHELF



The Expedition to Arnhem Land, (3) Botany and Plant Ecology

(University of Melbourne Press, 1958, xv+521 pp., 6 gns.)

The flora of the southern parts of Australia is reasonably well known and a considerable amount of detailed ecological work has been carried out on the vegetation. The position in the northern areas of the continent is, however, very different, our knowledge of the flora and vegetation being very incomplete. This is particularly so as regards Arnhem Land, the region lying west of the Gulf of Carpentaria, a large part of which has been constituted as a native reserve. Although many explorers, most of whom have made collections of the plants along their routes, have touched the fringe of Arnhem Land or have landed on its coasts during the past 150 years, it was not until 1928 that Dr Herbert Basedow visited the centre of the reserve. He made a considerable collection of the plants there but unfortunately practically nothing was published about these specimens, nor are any notes about them extant. The results of the joint American-Australian expedition, recorded in the book under review, are therefore all the more important, since they represent by far the most extensive collections which have been made in the region.

Most of these collections were made by Dr R. L. Specht, who is also responsible for a large proportion of the text of the book. The various groups of lower plants were, however, submitted to specialists who have contributed articles on their respective groups. Besides many new species and varieties of fresh-water algae, described by Drs Scott and Prescott, Dr Specht himself describes fifteen new species and six new varieties of phanerogams. In addition to the systematic accounts of the plants collected, there are chapters on the climate, soils, and vegetation of the reserve, on the geographical relationships of the flora, and a preliminary account of the ethno-botany of the region.

The parts which are of most general interest are those on the climate and ecology and on the geographical relationships of the flora, both of which are by Dr Specht. The ecological account is only a preliminary one since much of the area still remains to be examined in greater detail, while no adequate meteorological data are as yet available from the reserve itself. Nevertheless, from an examination of the communities in several areas visited, with the aid of aerial photography during two traverses of the interior, it has been possible to build up a general picture of the communities and to relate them to the climate and soil conditions. Following an account of the climate, geology and soils, the different plant formations are dealt with seriatim. All the communities described fall within the monsoon area of northern Australia, though with decreasing rainfall inland, from monsoon forest in the most favourable areas to open savanna woodland and grass steppe.

Dr Specht discusses rather fully the probable origin of the flora of northern Australia and its derivation from Indo-Malayan, Antarctic and Australian elements during various geological periods. He relates the present constitution of the flora and the vegetational pattern at the present day to the various migrations of these elements.

The book is clearly printed and illustrated with numerous text-figures, maps, and half-tone blocks. There is a reasonably comprehensive list of references at the end of each chapter.

V. S. SUMMERHAYES

Agricultural Research Council: Radiobiological Laboratory Report No. 1, Strontium-90 in Human Diet in the United Kingdom. 1958. H.M.S.O. 4s.

This is the first report to be published on this subject by the Agricultural Research Council since it was made responsible for investigating the contamination by radioactive substances of human food and agricultural land, and it deals with the measurement of strontium-90 in human food. Although technical, the report is intelligible to the layman and stresses that because strontium is laid down in the bone together with calcium, the crucial factor to be measured in the human diet is the ratio of strontium to calcium. Milk underwent the most intensive examination in a countrywide survey, both because it is the principal food through which strontium-90 enters the diet, and because it may be the sole diet of infants. Analyses of home-produced and imported flour, potatoes, and green vegetables were also undertaken. The mean ratio of strontium to calcium in the average diet of the whole population was then estimated at 6 $\mu\mu$c./gm. The report recalls the earlier warning of the Medical Research Council that immediate consideration would be desirable should the level in human bones show signs of rising far beyond 10 $\mu\mu$c.: having regard to the evidence gathered in the survey confirming that there is a discrimination against strontium relative to calcium by a factor of four in their passage from diet to bone, the warning-level in the U.K. would not be reached until the quantity of strontium-90 were six times greater.

Although the general finding was reassuring, there are none the less various causes for concern, not least the influence of the type of diet: specifically, the rather unexpected finding that wholemeal bread may lead to a higher concentration than a diet based on white flour fortified with mineral calcium. Then, too, there are extensive regional variations in strontium incidence—with some it is four times the national average. While even such figures are "safe", there is bound to be concern about the position of young children in these localities, bearing their actual diets in mind. It is good to know that these special areas are to be the subject of a further study, and it is to be hoped that the analysis will be concentrated on exceptional conditions which, while they may affect only a few persons, could be grievously serious.

D. GINSBURG

Bibliography of Articles and Papers concerning Radioastronomy

Compiled by W. Rae for the British Astronomical Association.

This bibliography containing some 400 entries, has been compiled on behalf of the Radioelectronics Section of the British Astronomical Association. It will give a guide on subject-matter to the energetic group of amateur astronomers now actively engaged in a number of radio-astronomical projects. In some branches of this new field of astronomy, teams of amateurs can make worthwhile contributions, as, for example, in the continuous monitoring of solar radio-emissions at various frequencies.

The bibliography is listed under six headings (General Works, Solar, Galactic and Extragalactic, Meteors, Aurorae, and Ionosphere, Lunar and Planetary, Radio Star Scintillations), each of which is subdivided into journal references. It covers most published papers, although by no means all, from the original discovery of cosmic radio-emission by Jansky in 1932, through to work reported in 1956. It is hoped to bring the document up to date every two years.

R. D. DAVIES

Inyanga. Prehistoric Settlements in Southern Rhodesia

By R. Summers, with contributions by H. B. S. Cooke, P. V. Tobias, H. Wild, J. F. Schofield and K. R. Robinson (*Published for the Inyanga Research Fund by the Cambridge University Press, 1958, 336 pp., 22 pls., 50s.*)

East African prehistory begins at least as far back in the Pleistocene as do archaeological records in any other part of the world. Unlike those of Europe or Asia, its written history opens only in the 16th century with fragmentary accounts of the interior by the earliest European explorers, so that its practically prehistoric period, in many parts, really extends down to times still within living memory. In the case of Southern Rhodesia, the British Occupation of 1890 marks its end.

The earlier stone-flaking and cave-painting cultures have evoked considerable interest and an already large literature. The later African inhabitants—making pottery, working iron, and building skilfully in dry stone—have escaped much serious archaeological attention, save for the builders of the more striking ruins, of which the best known is, perhaps, Zimbabwe.

The Inyanga area, nearly 3000 sq. miles in extent, in the middle of Southern Rhodesia's eastern border with Portuguese East Africa, offers the largest concentration of stone ruins in the country and forms the subject of this book, the outcome of three seasons' fieldwork, from 1949 to 1951, by the author as Director, and Mr K. R. Robinson as Assistant Director. Finance was provided by the Inyanga Research Fund, of which about one-third was subscribed by members of the Rhodesian community and business houses, the remainder by public bodies.

Forty sites were originally inspected and twenty-eight were finally excavated—a strenuous undertaking for only two trained archaeologists with a small African labour force. Many sites were comparatively slight and showed stratified deposits only 2–3 feet in depth, but the accurate planning, sectioning, and recording of finds, even in such structures, is not done in a few minutes, so that the field-work alone represents an enormous labour of organisation, supervision, and personal skill, which stands to the credit of the two Directors. Despite the magnitude of the task, the publication, now completed in detail, shows the care and thoroughness with which it was carried out.

Chapters I and II introduce the area, its known history and the surface evidences of its inhabitants—extensive cultivation-terraces, artificial watercourses, stone-revetted pits, enclosures, forts, cairns, and monoliths.

In Chapters III to VII descriptions and illustrations are given of the excavated sites, grouped according to their age and cultural affinities. This constitutes the full field evidence on which the later conclusions are based.

Archaeological finds of metal (mainly iron weapons and tools), pottery, stone, bone, and shell occupy Chapter VIII; the more important finds are illustrated in admirably clear line-drawings.

Chapter IX contains specialist contributions by H. B. S. Cooke and P. V. Tobias on the animal and human bones and a most interesting and important section on the botanical environment and determination of carbonised seeds from floors and hearths, representing nine species of cultivated plants, mostly cereals.

The late Mr J. F. Schofield has contributed a long and valuable essay, in Chapter X, on South African beads and their relation to those of Inyanga—a work of synthesis of more than only local application, summarising the results of his thirty years' study in this field.

Chapters XI and XII are devoted to the local background and the wider African view, and contain the overall conclusions of the principal author. With the available evidence before him he has interpreted the often insignificant-seeming details catalogued and described in preceding sections, in conjunction with the theories and conclusions of other authors from widely separated fields of African archaeology. Among others, we find comparisons with the results of the late Mr. F. Addison on the Wellcome excavations in the Sudan.

In Chapter XIII Mr Robinson describes three Stone-Age sites excavated in the Inyanga district, incidental to the main investigation of the ruins.

The last chapter is an outline history of the area studied, compiled from all these sources. It is followed by four Appendices, which will be of great assistance to the student, if not to the general reader. Catalogues and tables may make dull reading if included in the text, but are essential to the author in the first construction of such a book, and are too seldom published for the benefit of the specialist reader also.

As one of the few accounts of systematic excavation bearing on a pre-European iron-working people of East Africa, this work is a landmark and a vivid example to be followed elsewhere. Southern Rhodesia is fortunate, not only in its own active official archaeologists, but in an interested and generous section of the public, which has made this publication possible. I. W. CORNWALL

Commercial and Industrial Photography

By David Charles (*London, Chapman & Hall, 1953, 402 pp., illustrated, 52s. 6d.*)

This is an intriguing book; it is entertaining, instructive, and yet disappointing. The author was an outstanding and acknowledged authority in the days before the war, when good photographic technique was based on experience alone. His background and intelligence have enabled him to analyse and apply his experiences in a logical and systematic fashion. Wherever these qualities are reflected, the text is most enjoyable. Those who know something about photography already will appreciate his individualistic and often unconventional approach. Some of his observations and conclusions are of outstanding interest and are indicative of his great teaching abilities.

It is the more disappointing to find that the author has tried to mention too many aspects of photography. Whilst, for instance, fire precautions in connexion with pre-war inflammable film-base is discussed at length, ultra-violet and infra-red recording is mentioned on one page, and then only in very general terms which do not really contribute to the reader's knowledge, either theoretical or practical. Again, this superficial treatment for the sake of complete coverage has lead to statements which, unless they are qualified, may well mislead the student. It may here suffice to quote from page 213: "Plates and paper of kinds which are not specially sensitized for colours, i.e. 'colour-blind' emulsions and bromide papers, are sensitive to ultra-violet."

No doubt a new edition will be required before long. It is to be hoped that Mr Charles will then be able to persuade his publisher to accept a modified text, which restricts the contents to the author's personal contributions. Such a monograph would contribute greatly to a proper balance between practical common sense and the present emphasis on a scientific approach to problems of photography. This publication makes profitable bedside reading *par excellence*; it is far more than a textbook. C. E. ENGEL

Electronic Apparatus for Biological Research

By P. E. K. Donaldson (*Butterworths Scientific Publications, 1958, 718 pp., illustr. 120s. net. New York, Academic Press Ltd. $20.00*)

Lest the reader is slightly misled by the title, it may be said at once that this is *not* a catalogue type of book describing various research equipment and how to use it. It is a first-class treatise on electronics with particular application to the needs of biological and physiological measurement, and as such should be in the library of all medical research units and teaching centres.

Your reviewer has a particular interest in the appearance of this work because it was not long after the end of the war that the need for a book on electronics

A WONDERFUL MONEY-SAVING OPPORTUNITY FOR EVERY READER OF DISCOVERY!

FULL LENGTH FULL SIZE!

Now's the time to join the

Scientific Book Club

121 CHARING CROSS RD., LONDON, W.C.2

A FIRST-CLASS SCIENTIFIC BOOK EVERY MONTH FOR

ONLY 4/-

FREE GIFT
'SKY-LINE'
KITCHEN TOOL SET

When you join, you can obtain a five-piece Prestige "SKY-LINE" KITCHEN TOOL SET free if you enrol a friend in the Club. Send your friend's name and address with 5s. (4s. plus 1s. postage) for the first book, mentioning this offer, and your Kitchen Tool Set will be sent to you.

ALL THESE GREAT TITLES

Recent and forthcoming selections include:

THOMAS TELFORD
By L. T. C. Rolt
Published at 25s.
4s. TO MEMBERS

★

ELEPHANTS
By Richard Carrington
Published at 25s.
4s. TO MEMBERS

★

ATOM RUSH
By Harold Steinert
Published at 18s.
4s. TO MEMBERS

★

VIRUS IN THE CELL
By J. Gordon Cook
Published at 12s. 6d.
4s. TO MEMBERS

★

OF FISH AND MEN
By Jon Miller
Published at 18s.
4s. TO MEMBERS

The Scientific Book Club is owned and controlled by Foyles, the world-famous booksellers.

Here is a wonderful money-saving opportunity for every reader of Discovery! Each month, the Scientific Book Club brings to its members the fascinating story of the march of modern science, told in thoroughly dependable books by the front-rank scientific writers of our time—vivid, vital, constructive contributions to Man's unceasing struggle to solve the problems of the Universe.

And although the ordinary editions of these books are sold to the general public at 12s. 6d., 15s., or more, THE PRICE TO MEMBERS OF THE SCIENTIFIC BOOK CLUB IS ONLY 4s! Remember, too that Scientific Book Club selections are *full-length and unabridged*. They are printed on good-quality paper, well bound, with an attractive picture jacket. And if you introduce your friends to the Club you receive grand free gifts—books, pictures, furniture or the handsome Kitchen Tool Set described above.)

These are, we say with certainty, books that you will be glad to read, proud to own. The Scientific Book Club brings these great books to you each month; helping you to build up, at remarkably low cost, a first-class collection of scientific books. **Now is the time to join!**

EXCELLENT PRODUCTION

Legible modern type is used for all Scientific Book Club selections. The pages are designed with ample margins and every book is carefully planned for comfortable reading. The Scientific Book Club's selections have been widely praised for the high standard of their production.

FILL IN THIS ENROLMENT FORM TODAY

To the Scientific Book Club, 121 Charing Cross Road, London, W.C.2

I wish to join the Scientific Book Club and agree to purchase the selected book issued each month to members at a cost of 4s. (postage 1s.). I agree to continue my membership for a minimum of six books and thereafter until I cancel.

You may enrol through your usual bookseller if he is a member of the Booksellers' Association.

☐ *** I will pay for selections on receipt.** Discovery/November 59

Or if you wish to save time, postage and postal-order costs, you may send an advance subscription. Six months 30s.; twelve months 60s.

☐ *** I enclose 30s./60s. (strike out amount not applicable).**

* Place ✓ in the space above, as required.

Name .....

BLOCK LETTERS PLEASE

Address .....

Overseas enrolments should be accompanied by an advance subscription. Prices as for inland (except South Africa, Australia, New Zealand)

for the physiological technician was discussed and the idea was welcomed by many of his colleagues. Unfortunately, the idea did not materialise, although a useful short book on the subject was published by Morgan Bros. some years ago.* Now Mr Donaldson has supplied the want and deserved the gratitude of the growing army of medical researchers. As Sir Bryan Matthews says in his foreword for over twenty-five years electrophysiological research students in Cambridge have been encouraged to construct their own apparatus and master the electronic principles involved, and this book contains the essence of all that they have had to learn under Mr Donaldson together with the know-how based on his own experience in the laboratory.

The emphasis throughout is on techniques: the individual application is left to the reader to devise, and with a knowledge of the theory given in Part I and the practical information in Part II he should have no difficulty in constructing any particular unit for a specific purpose.

Part III is a collection of chapters by various specialists on transducers, electrodes and indicators, and includes notes on the measurement and control of temperature, humidity, radioactivity assay, together with glass and other electrodes. Part IV, dealing with complete apparatus, also covers methods of recording, layout of circuits, faults, and some hints on design procedure. The use of magnetic tape as an intermediate recording medium is mentioned as a useful possibility: it can be used repeatedly and can be edited so that only those portions worth keeping are transferred to a photographic record by way of a cathode-ray tube.

In a treatise of this size it would be a marvel if there were not one or two slips, but these would only be evident to a born and bred electronic engineer and they do not detract in any way from the excellence of the writing and presentation. It is certainly the electrophysiologist's *vade mecum*. G. PARR

Cosmic Electrodynamics

By J. W. Dungey (*Syndics of Cambridge University Press, 1958, 36s. 6d.*)

The phenomena of solar activity, aurorae and magnetic storms, and the existence of the earth's magnetic field with its variations, have long forced astrophysicists and geophysicists to take electromagnetism seriously. In the last decade or so the scope of cosmical electrodynamics has broadened enormously. The discovery of magnetic stars has shown that our sun is not unique or even specially remarkable in its magnetic properties. There is now convincing evidence for a strong large-scale galactic magnetic field, from several independent lines of argument; and study of the proceedings of the three international symposia held since 1949, on cosmical gas dynamics, shows strikingly the greatly increased importance of electromagnetic forces in current theory. Astrophysical problems have inspired general theoretical study of the interaction between the electromagnetic field and the density-velocity field of a conducting fluid, a subject of vital importance for thermonuclear research.

In his book, Dr Dungey devotes most space to basic physical principles and simple illustrative models, rather than attempting to explain in detail any particular set of observations. From the start he emphasises the differences between cosmical and ordinary laboratory electrodynamics: the primary importance of self-induction, leading to an inversion of the usual cause-effect relation between magnetic field and current, and the approximate "freezing" of the field into moving matter. The finite resistivity of an ionised gas and the Hall effect are among a number of causes of relative motion between the field and the gas, but the author is careful to point out the danger of trying to follow the motion of individual lines of force of a general field.

Various magnetostatic models are computed, both for their mathematical simplicity and their probable relevance to certain features of the solar surface, in which inertial forces appear to be small. The chapter on magnetodynamics contains a qualitative discussion of rotating fields and magnetic variable stars, and some mathematical treatment of Alfvén waves, hydromagnetic stability problems, and the vexed question of turbulence and magnetic fields. Three processes for the acceleration of charged particles to high energies are treated: the betatron mechanism, discharges at neutral points of magnetic fields, and the ingenious Fermi mechanism in which the particles attempt the impossible task of achieving equipartition of energy with turbulent magnetic clouds. The book closes with a largely qualitative treatment of solar activity and solar-terrestrial relationships, and a survey of ionospheric electrodynamics.

There is one surprising omission from the general theory—there is no explicit statement of the energy theorem for either a fully or partially ionised gas, which would show clearly how a velocity field, driven by non-magnetic forces against the Lorentz force, will pump energy into the magnetic field. The contrast with laboratory electrodynamics can be further brought out by considering a battery trying to build up a magnetic field against self-induction. The Lorentz force cannot easily distort or move a solid conductor, but it can set a gas in motion; unless there are non-magnetic forces opposing the Lorentz force, the energy from the battery will become kinetic rather than magnetic energy.

The book is a welcome addition to the present literature in this field, and can be recommended both to astronomers and to plasma physicists. L. MESTEL

Doctors to the World

By Murray Morgan (*New York, The Viking Press, 1958, 271 pp., $5.00*)

Mr Morgan travelled 28,000 miles as an independent reporter studying the work of the World Health Organisation in combating diseases. He visited twenty-two countries in four continents and found that several diseases were being fought simultaneously in many of the countries. By concentrating on a single campaign against one disease in each country, he describes the international battle against sickness in the face of local hostility and superstition, and in spite of insufficient staff and funds.

Firefly in the Night: a Study of Ancient Mexican Poetry and Symbolism

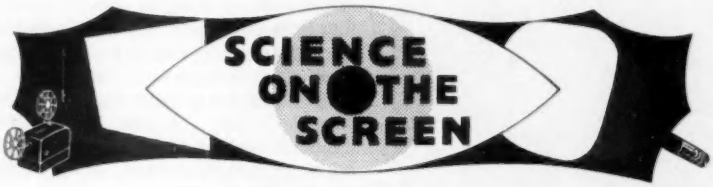
By Irene Nicholson (*London, Faber & Faber, 1959, 25s. net*)

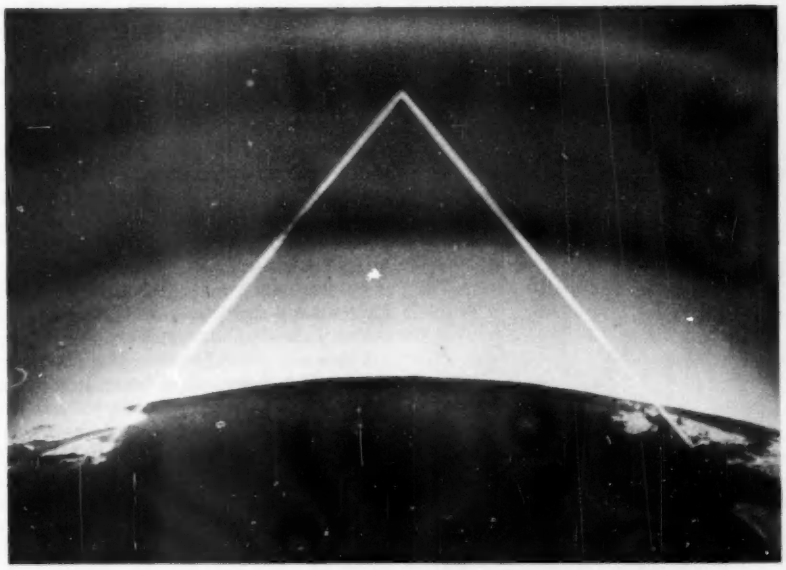
Miss Nicholson has presented us with a good deal of material which has never before appeared in English. Our knowledge of the philosophy behind the ancient civilisation of Mexico is greatly extended. In the field of natural science one is puzzled by the curious gaps in knowledge of the ancient Mexicans. Their astronomical observations reached a degree where eclipses could be dated for centuries ahead or into the past. Yet there is no clear idea of the relationship between moon, stars, and planets. The only planet securely recorded was Venus. The others were known, but, so far, their astrological symbols are not identified. In Mexico the concept of layered heavens does not appear to have originated in a theory of planetary spheres but through the apparent perspective of the night sky. On page 39 Miss Nicholson reproduces a drawing of sun, moon, and the layers of stars, from the Selden Roll, preserved in the Bodleian Library. C. A. BURLAND

Brief Note

Catalogues of forthcoming books are now available for the following publishers: Brockhampton Press (books for young children), Blackwell Scientific Publications,. Max Parrish & Co. Ltd., A. Asher & Co. (publications on Natural History), John Murray.

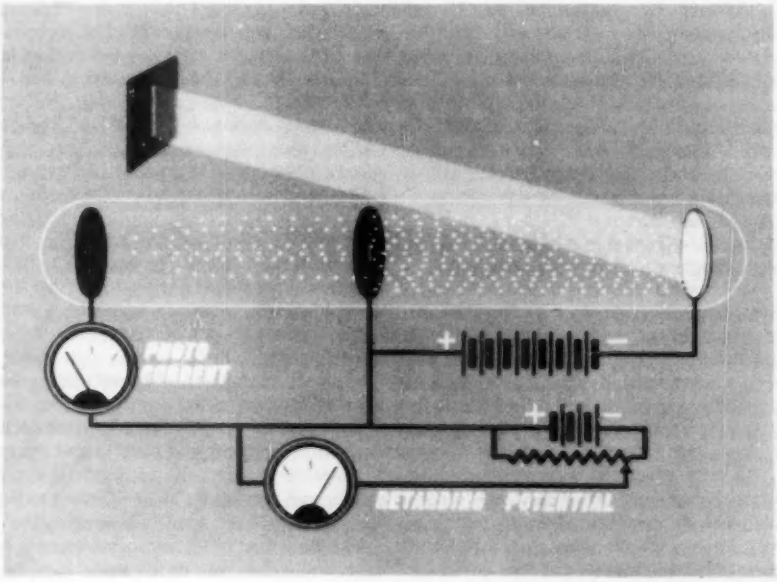
* "Electrophysiological Technique", C. J. Dickinson, 1950.





Animated diagram in realistic setting, showing reflection of short radio waves from Appleton layer. From "Mirror in the Sky" (Harrogate prize-winner, 1957. Middle range school.)

Animated diagram to explain visually the processes of an experiment. The apparatus used for determining the maximum energy of emitted electrons in photo-emission. From "Photo-Emission". (Advanced Science Series.)



EFVA to Improve Science Teaching by Films

The foundations of science are in our schools. Today the teaching problems are vast: many textbooks are twenty or more years old; the changes in the orientation of physics and chemistry, which have come with new developments, have not been available to the teacher who is trying to keep up with his syllabus; and nearly all the available science-teachers are in the grammar schools.

The Educational Foundation for Visual Aids is trying to meet the educational demand for films and filmstrips on all subjects. As science is a new and urgent problem they are making special efforts to supply films to teach, films to catch the interest of the pupil, and films to introduce the eight-year-old to the age in which he is living.

Film can do a lot. It can bring to the screen the leaders in every field of science. It can film the best research equipment and expensive experiments which are beyond the reach of any normal school. The latest knowledge can be made available whilst it is still brand new. In fact, film, if necessary coloured, is unique in this field.

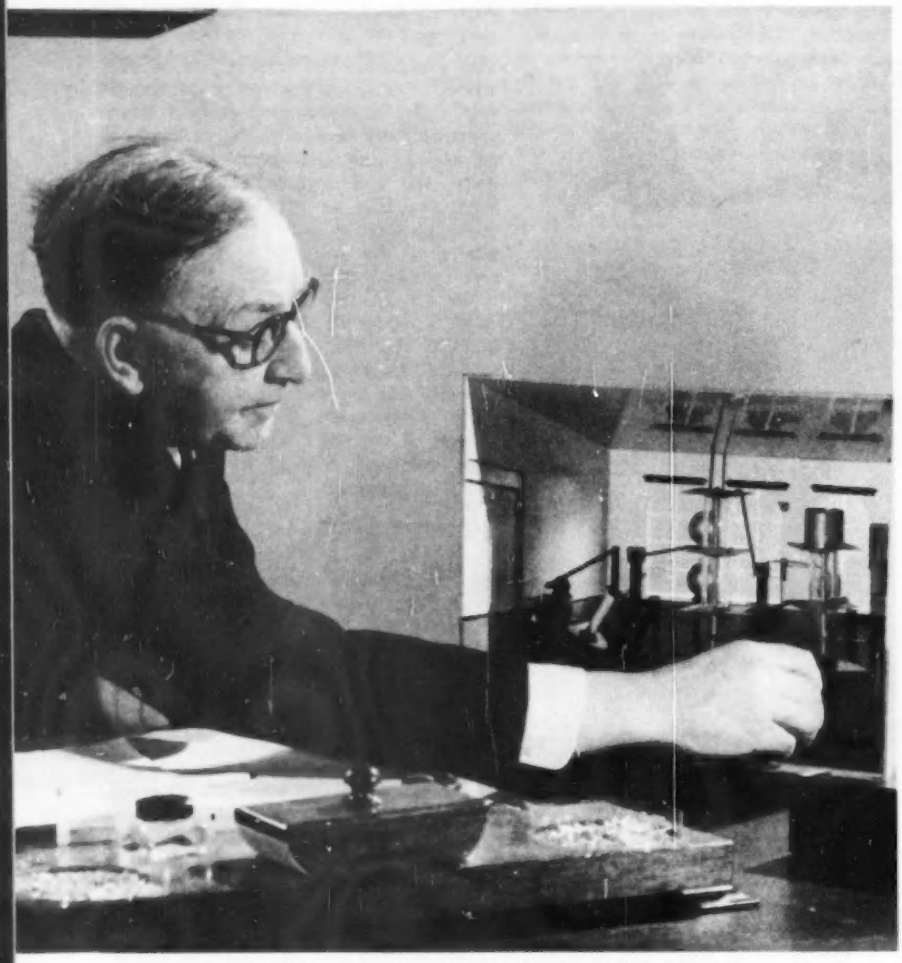
EFVA has wisely realised the limitations of the scientific teaching film. It is best used to put over a limited subject to limited audiences. All too often films try to be all things to all men. What emerges is a half-baked encyclopaedia with bits of knowledge, some of which are suitable to the research physicist and others to the twelve-year-old.

These teaching films are made in co-operation with the National Committee for Visual Aids in Education. Applications for hire of these films should be made to The Foundation Film Library, Brooklands House, Weybridge, Surrey. Orders for purchase should be made to the Educational Foundation for Visual Aids, 33 Queen Anne Street, W.1.

The international reaction to these films would seem to show that they are a unique contribution to scientific education, for they are distributed to between forty-five and fifty countries. Dr Harrison, Director of EFVA, estimated when the series was first proposed that there would be a demand for approximately thirty copies of each title; in fact the demand has been nearer two hundred copies per film.

The great advantage from the teacher's point of view is that by seeing the film and reading the notes he can bring himself completely up to date; and of course he can do it without displaying the lacuna in his own reading.

At present eleven films have been finished and the twelfth is being made More and more firms, both large and



Sir John Cockcroft explains, on a model of his original laboratory, one of his famous experiments—splitting the lithium atom.

small, are needing highly skilled scientific technicians in their day-to-day work. They will not find them unless the schools are producing youngsters of the calibre they need. It is more and more apparent that industry must help finance the State and the private schools and universities in their task. One immediate way is to provide sponsorship for scientific teaching films.

The experience of The Educational Foundation is that teachers will not willingly use public relations or advertising films. There is not time in the crowded programme as the examinations get near, to see how beans get into a can, or how a motor-car is assembled. On the other hand, industrial films which tell a real scientific story can get distribution on a large scale. This is not an appeal; it is an objective statement of fact.

Here are brief reviews of some of the films in the Advanced Science Series.

Principles of Ultrasonics: 16 mm. Sound, B. & W., 1¼ reels. 15 min. Presented by Mullard Ltd, in conjunction with EFVA. EFVA No. 538 Al. Purchase price, £18; hire 10*s*. 6*d*.

Clearly and simply, the film shows the relationship between ultrasonic and sound waves. Using demonstrations beyond the possibility of most schools and good, simple diagrams to show the propagation of waves with the magnetostrictor and crystal transducer. It goes on to show the properties of ultrasonic waves and the useful and dangerous effects. Like all good educational films, it ends with a recapitulation, and shows that there is still a vast opportunity for expansion and development in this field.

Although excellent in content and in scientific demonstration, the few scenes which could have been treated imaginatively, such as those showing the bat and the dog, which have a greater sensitivity to ultrasonic waves than we have, are rather drab. It is highly desirable that the film technician, when possible, should use his artistic skill, although this use must never obscure the real message.

Principles of Nuclear Fission: 16 mm. Sound. Colour. 10 min. Presented by United Kingdom Atomic Energy Authority in conjunction with EFVA. EFVA No. 558 D6. Purchase price, £25; hire 15*s*.

With a clear, slow commentary, model-type animation shows the historic and modern conceptions of atomic structure. The relation of the basic particles, electrons, protons, and neutrons is shown, followed by the ways in which these particles can be used as missiles to break down other atoms. The fission of uranium 235 and the production of chain reactions is demonstrated.

The second part shows a nuclear reactor in actuality and with models. Unfortunately, this part is not quite as good as the first, mainly because the sequences are not very clearly demonstrated.

There are other films on **The Spectrograph**, **Principles of Chromatography**, **Friction**, **The Linear Accelerator**, **Discharge Through Gases**, **X-ray Crystallography**, **Principles of the Transistor**, and **Vacuum Practice**, all of which are thoroughly practical, well authenticated teaching media.

From the middle school to the arts sixth forms information and stimulation are necessary if the non-scientists of the future are to understand the role and function of the scientist in the modern world. We have explored beyond the Ultima Thule in this world of ours. So scientists must investigate the infinitely small and the unbelievably large universe. The first films in these series have appealed equally to adults. They go beyond the popular-science treatment without being complex.

Mirror in the Sky: 16 mm. Sound. B. & W. 2 reels. 20 min. Presented by Mullard Ltd in conjunction with EFVA. Hire 15*s*.

The story of Appleton and the ionosphere is a story of research and discovery into the development of radio and the discovery of the Heaviside layer and the Appleton layer. It started in 1867 when James Clerk Maxwell forecast the nature of wireless waves. It passes in review the work of Hertz, Marconi, and others until radio became an established part of our everyday life.

With diagram and demonstration the work of Heaviside and Appleton is shown and how their discoveries led to research stations being set up all over the world to keep watch on the behaviour of the ionosphere and predict how it will effect radio reception.

The new science of radio-astronomy is covered, even the dark stars can be

observed, because they emit radio waves. Radio telescopes can probe into the nature of the universe. Through the years a series of scientists each contributing their own discoveries make possible new and more far-reaching achievements for their successors.

The historical scenes are well reconstructed and the characters are reasonably well acted. Your reviewer was impressed by the method of diagram animation. It uses semi-realistic backgrounds which make these scenes less abstract than they might easily have become.

Each child is issued with a pamphlet which he can take home and read at leisure. This helps to give the film lasting impact. This is especially useful as these omnibus films arouse great momentary interest, but are inclined to be forgotten very soon.

Though country children can obtain practical knowledge of botany, this is unfortunately divorced from the lives of most urban children.

To counteract this, EFVA is trying to produce a series of films more related to children's everyday experiences. The children who never see a cow are familiar with electric light, radio, TV, and the internal combustion engine. They see coal in the grate and gas under the kettle. They drink the water which comes out of the tap and they see clouds and rain. Therefore, instead of botany they should have the simple stories of electricity, of coal and gas, and of the water cycle.

An educational film can be described as a visual digest of material which can best be shown. The commentaries can be completely precise and absolutely clear. The best film in the world cannot replace the teacher and cannot be a substitute for the science teachers who are not coming forward in sufficient numbers. The Italians are experimenting with television school, in which complete lessons are televised, including the children in the studio class asking questions. This is unlikely ever to replace satisfactorily the personal contact between teacher and pupil unless our knowledge of psychology allows us to create a real, satisfactory teaching situation without personal contact.

The Educational Foundation for Visual Aids is trying hard to supply a real answer to these problems. By calling in high-level experts and teachers from the schools they endeavour to allocate priorities so that the little money available is used to the greatest advantage. The only thing that is necessary is a tie-up with industry which will allow them to make the films that the schools need. This in its turn will make the new generation science-conscious, help teachers to keep up to date and act as vocational guidance.

L. GOULD-MARKS

New Term and Television

Now that the new school term has started, the broadcasting authorities have lost little time in announcing the details of the new schools' science television programmes to be broadcast by both channels. ITA have announced a weekly series, "The World Around Us", which promises to be really exciting. These programmes are meant for the top classes in Primary Schools and for the lower forms in Secondary Schools. They will be transmitted, as usual, at 2.45 on Tuesday afternoons, with repeats on Thursdays. Extra repeats have been inserted at half-term for the benefit of those whose short mid-term break might lead to a miss. This is a thoughtful detail.

Of the first eight programmes to be given (the work for the term) the odd numbers will be a "Conquest" series, dealing in succession with Antarctica (1), Everest (3), Flight (5), The Mayflower Pilgrims (7). The even numbers will deal with Air we breathe (2), Spring of air (4), Water and our bodies (6), Water in work and play (8). Judging from the excellent notes issued for the use of teachers, there will be some good material, and your reviewer looks forward to stealing some time off to look at some of these programmes.

The BBC, too, announce a comprehensive programme for the term, and offer "Science and Life", broadcast at 2.05 on Wednesdays, with repeat on Thursday morning. The target is the 12–14 age-group, the subject "The World in Space". The successive programmes will deal with (*a*) Voyage in space, (*b*) The Moon, (*c*) Telescopes, (*d*) The Earth, (*e*) The Earth's crust, (*f*) The atmosphere, (*g*) Exploration of the atmosphere, (*h*) The ocean. Although necessarily elementary, this series seems to be comprehensive and should certainly arouse a good deal of interest in children—*Sputniks* and rockets have certainly made every youngster very space-conscious. Simultaneously with these television broadcasts, the BBC have comprehensive science schools' broadcasts on *sound* only. These include separate courses on "Science and the Community", "Nature Study", and also "General Science".

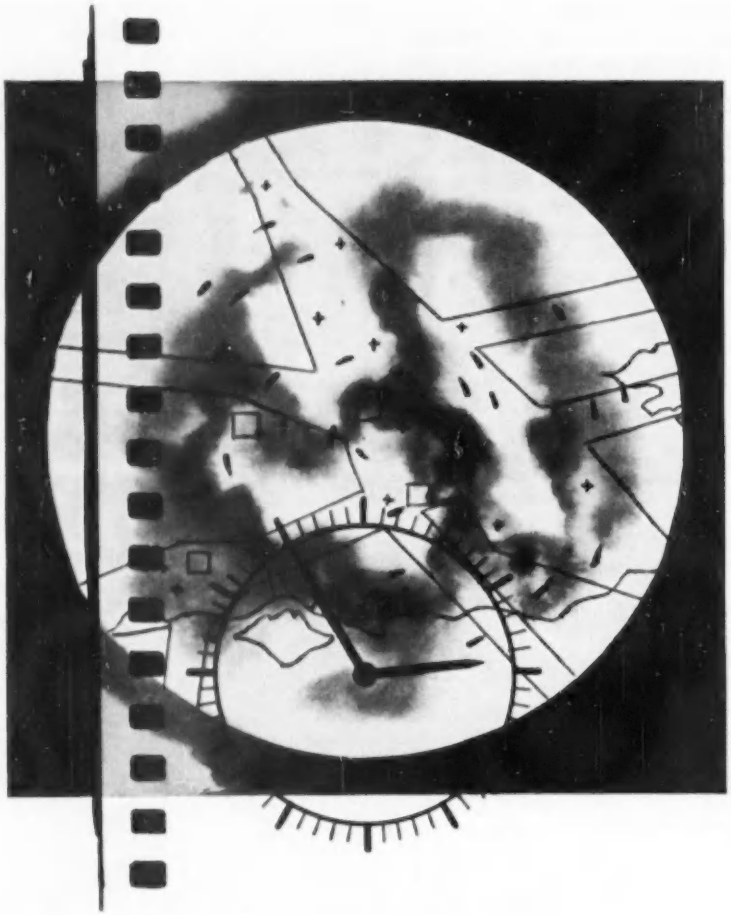
It is to be hoped that adult science television will be as lively as the schools' broadcasts promise to be. For during September, apart from the regular monthly "The Sky at Night" from Patrick Moore on BBC there were only a succession of occasional brief films which varied considerably both in style and quality. On September 24 an Austrian film on the "Language of Bees" was shown. On September 25 Peter Scott gave us Part 2 in his series "Faraway Look". This was an essentially silent film of wild animal life in the jungle in Trinidad, with a running commentary on the film from the studio conducted by Peter Scott and his wife. Though a very personal record, it was a rather disconnected travelogue. It was very much like showing holiday snaps —a bewildering *ad hoc* collection. Peter Scott also gave us another "Look" film programme in the Children's Hour on September 29.

Certainly the best scientific film of the month was that broadcast on September 10 under the title *Scientific Curiosities: Cold*. It was a 15-minute silent film produced in the Low Temperature Section of the Clarendon Laboratory at Oxford by James McCloy. Despite some outstanding scientific demonstrations of great difficulty, which were made to look ridiculously simple to the uninitiated, it was regretfully one of those all-too-common science films which is, strictly speaking, a silent film, dubbed and accompanied by some expert commentator (in this case Michael Flanders, who has a fine speaking voice). Such an arrangement is a poor substitute for a sound film and a still poorer substitute for a live studio broadcast. Indeed the silent wraith-like movements of some of the experimenters, the bubbling over of boiling liquids without a sound, the close-up of the switching-on of a pump, and no subsequent sound, all had a slightly comic air which destroyed a good deal of the illusion that television usually hopes to create—the illusion of being actually present. This was rather disastrous in the circumstances for the experimental demonstrations were rather unique.

The scientific content of the film was outstanding and we saw some really novel improvements on the stock liquid-air experiments which are by now becoming rather monotonous on science television broadcasts. Instead we saw a frozen mercury hammer in action, a lead bell ringing when struck (so we were told, it was all mimed of course), and a good demonstration of the magnetic properties of liquid air. A really fine demonstration, new, your reviewer is sure, to television and most impressive to the scientist, was the production of a really big chunk of *solid* air from rapidly boiling liquid air.

With considerable experimental courage the demonstrators then showed numerous experiments with liquid helium: superconductivity and indeed some of the unusual physical properties of helium II were actually shown. It was experimentally a veritable *tour de force* and it is a great pity that this was not a sound film with a recording by some of the scientists at the Clarendon Laboratory who made the film possible.

S. TOLANSKY



A vigilant eye on the sky . . .

Over busy airports the pattern is always changing. Sleek aircraft pass, circle, and approach as moving "blips" on a screen—and so, through the vigilant eye of radar, danger is seen and danger averted.

To guard against lapses of memory, photographic repeater equipment now provides airport officials with permanent and incontrovertible evidence of a pilot's obedience to control from the ground. At each successive sweep of the radar scanner, this all-in-one combination of camera, processing apparatus, and projector photographs the screen, advances the film, and developes the image so that it can be viewed six seconds after the exposure is made.

Successful operation of this ingenious aid to safety depends on special ILFORD films and processing solutions produced to the requirements of the designers—a fact which gives added emphasis to the high standards of performance and reliability for which ILFORD products are world-famous.

ILFORD PHOTOGRAPHIC MATERIALS

ILFORD LIMITED · ILFORD · ESSEX

FAR AND NEAR

Observing the 1959 Perseid Meteor Shower

Practical meteor observation requires little or no expensive equipment, and is an ideal field for the serious amateur observer. During the period July 27–August 17, members of the Croydon and Leeds Groups of the Junior Astronomical Society made a survey of the 1959 Perseids, and in order to avoid industrial haze and artificial lighting a party of observers, aged between 15 and 20, camped on a farm close to the Sussex South Downs. During the period, observing conditions were extremely good. The JAS Groups were also in touch with similar groups in America and Europe.

In analysing the results, an attempt has been made to determine the distribution of brightness in connexion with the height of the meteors, the zenith hourly rates, and an approximate radiant for each night. Observations of colours and duration were also recorded.

The night of August 11–12 marked the predicted maximum period of activity, but unfortunately weather conditions on this night were poor. On the morning of August 15, however, 56 Perseids were seen. In general, the shower displayed a slow rise during the two weeks prior to maximum, a fairly rapid rise to a broad peak, and a slow decline thereafter until August 17, when the shower was barely in evidence. Out of the 172 meteors observed, 131 were classified as Perseids, most of which were white in colour. The most spectacular meteor observed equalled the brilliance of Venus at maximum (magnitude 4½), while the average magnitude of recorded meteors was 1¼. It is hoped that the results of the admittedly ambitious programme carried out by JAS members will be of some value in the overall analysis of the 1959 Perseids.

British Clock for Australia

A clock which will not gain or lose more than a second in twenty-five years is to be installed in the Australian Post Office Research Laboratories at Melbourne by a team of British scientists. The clock, which has been constructed at the Ministry of Supply Signals Research and Development Establishment, Christchurch, Hants, is known as an ammonia maser, is accurate to within one ten-thousandth of a second per day and will be the first of its kind in the southern hemisphere.

One job for which the maser will be used is the measurement of the rate at which electric pulses sent out by a radio transmitter near Rugby are received in Melbourne, some 15,000 miles away. Although the transmitting rate is constant, the pulses are not received at a constant rate, due to variations in the ionosphere, the radio "mirror" which surrounds the earth. The maser will be used to measure these variations, providing more information about the ionosphere.

An ammonia maser relies on the natural vibrations of ammonia gas molecules, which produce electric pulses at the rate of 24,000 million a second.

Air-Car

The Curtiss-Wright Corporation of Detroit, Michigan, is planning to produce its first "air-car" by November. The principle is apparently similar to the one used for Ford's "Glideair", and for the projected "Hovercraft" car of the future. The Curtiss-Wright air-car travels on a cushion of low-pressure, low-velocity air, and will be powered by two engines developing 300 h.p. between them. (The British reader will immediately ask about the mileage per gallon, but nothing has been said so far about this point.)

The design has no wheels, no transmission or clutch, but is supposed to travel at a top speed of 60 miles an hour. The external shape of the vehicle resembles a conventional motor-car, except that it has two circular discs in place of the usual bonnet and boot. The usual mudguards are replaced by a continuous vertical shield, which is pierced with a series of louvres or vents. The car is 21 ft. long and weighs about 1700 lb. Passenger accommodation for four persons is provided for, and its price will be higher than for a standard type of car.

The main claim for this interesting invention is that the vehicle can move over unpaved land, water, swamp, or any unobstructed but rough terrain at a height of about 6 to 12 in. off the ground. Further details of the design have not been disclosed.

Hungary Opens First Atomic Reactor

Hungary's first experimental atomic reactor is now in operation. It began working in March, and it is reported that it is now operating at full capacity.

It is a small reactor of 2 MW capacity, and was built with the help of the Soviet Union. It stands in the Buda Mountains, above Budapest. The installation is fully automatic.

Mr Arpád Kiss, President of the National Planning Office, said that the reactor was primarily for research work, and particularly for the training of nuclear technicians. Experience gained from the new reactor will be used in the future planning and construction of atomic power stations in Hungary.

New Norwegian Technological Institutes

Two valuable additions were recently opened at the Norwegian Institute of Technology in Trondheim. One is the brand-new Institute for Materials Technique, largely financed by SINTEF—the Society for Industrial and Technical Research. The other is the Waterways Laboratory, which replaces provisional facilities in the main university building. Contributions from private industry and allocations from proceeds of Norway's soccer betting pool have helped to pay for both projects.

Classified Advertisements

OFFICIAL APPOINTMENTS

PHYSICISTS required for Research and Development Establishments in MINISTRY OF SUPPLY with well-equipped laboratories mainly in southern England offering wide range of work INCLUDING SOLID STATE PHYSICS, RADIO-ASTRONOMY, SPACE RESEARCH, LOW TEMPERATURE PHYSICS, AIRCRAFT PROJECTS, BALLISTIC MISSILES, GUIDED WEAPONS, ADVANCED COMPUTING TECHNIQUES, OPTICS, ELECTRONICS, RADAR, TELECOMMUNICATIONS, GAS TURBINES, AEROSOLS, INDUSTRIAL COMPRESSED GASES.

Appointments in grades of (*a*) SENIOR SCIENTIFIC OFFICER (£1166–£1380), (*b*) SCIENTIFIC OFFICER (£615–£1090). Starting salary according to experience. Superannuation under FSSU. 1st or 2nd Class Honours degree or equivalent required and for (*a*) at least three years post-graduate research experience. GOOD PROMOTION PROSPECTS. Forms from MLNS, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.437/9A/PG.

GOVERNMENT OF THE FEDERATION OF RHODESIA AND NYASALAND VACANCIES: ENTOMOLOGISTS MINISTRY OF AGRICULTURE

(1)

APPLICATIONS are invited for two posts of Entomologist in the Federal Department of Tsetse and Trypanosomiasis Control and Reclamation, Southern Rhodesia.

Applicants must possess a degree, preferably honours, in a biological subject—Zoology, Entomology, or Botany. Applicants need not have specialised in Entomology, but either an entomological or ecological training will be an advantage.

The successful applicant will be employed largely on field investigations preparatory to tsetse control projects, and in their direction.

(2)

Applications are also invited for a post of Entomologist in the Entomology Branch of the Department of Research and Specialist Services.

Applicants must be graduates, preferably with honours, having Entomology or Zoology as a principal subject. A knowledge of tropical or subtropical entomology would be an advantage.

Duties involve laboratory and field research, investigation on insects and other invertebrates, particularly those of economic importance, in addition to extension and advisory work on agricultural entomology.

Commencing salary between £700 and £1250 per annum depending on qualifications and experience in the scale £700×100–£1100×75–£1250×50–£1650 per annum.

Applicants should state whether they wish to be considered for posts in only one or both Departments.

Application forms and further details from the Secretary (R), Rhodesia House, 429 Strand, London, W.C.2.

RESEARCH FELLOWSHIP HIGH POLYMER PHYSICS

APPLICATIONS are invited by Ministry of Supply for a JUNIOR or SENIOR RESEARCH FELLOWSHIP concerned with the physics of high polymers and tenable at the University of Bristol under the direction of Prof. F. C. Frank, Department of Physics.

The Fellow will join a small group studying the basic structure and physical properties of high polymers employing a wide range of modern techniques. Contact will be maintained with related research work in progress at Ministry of Supply Establishments.

Candidates must be British subjects with normally a First or Second Class Honours degree in Physics or Physical Chemistry and with evidence of high ability in research. At least two years' post-graduate research experience required for JRF (age preferably 23–26) and three years for SRF (age preferably 26–30).

REMUNERATION according to individual merit and experience on ranges £1150–£1400 (SRF), £800–£1100 (JRF) a year. Superannuation under FSSU. The Fellowship will be held for two or three years, and at expiry the holder can be considered for an established post in the Scientific Civil Service.

APPLICATION FORMS from Assistant Director, Est. 3.R., Adelphi, Strand, London, W.C.2.

LABORATORY SUPERINTENDENT required by the Western African Council for Medical Research for Onchocerciasis Research Unit, Bolgatanga, Ghana, for two tours of 15/24 months in first instance. Salary in scale (including Inducement Pay) £990 rising to £1660 a year, commencing salary according to experience. Gratuity at rate £100/£150 a year. Outfit allowance £60. Free passages for officer and wife. Liberal leave on full salary. Candidates must be A.I.M.L.T. and should preferably have had experience in field and laboratory research in parasitology and entomology in the tropics. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M3C/52826/DI.

FELLOWSHIP IN CHEMICAL ENGINEERING

DIVISION OF PROTEIN CHEMISTRY COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION, AUSTRALIA

APPLICATIONS are invited from Honours graduates in Chemistry or Chemical Engineering (or equivalent) with some years' relevant post-graduate experience for a FELLOWSHIP IN CHEMICAL ENGINEERING at the Organisation's Division of Protein Chemistry, Melbourne. The Division is engaged on intensive studies of wool and wool proteins using electron microscopy, x-ray diffraction, and many similar modern protein techniques, and it is now proposed to add chemical engineering techniques to extend protein research in several promising directions. Appointment is initially for three years and the appointee is required to develop facilities for extension of pilot plant investigation of a cold solvent dyeing method, a rapid sheep-skin digestion process, and a wool carbonising process; also to apply chemical engineering methods and results of protein research in furthering the development of new processes and improving wool textile processing generally.

SALARY: dependent on qualifications and experience within the range £A1400–£A2300 per annum.

Fares paid. Further particulars of duties, conditions, etc., supplied on application to Mr E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, to whom applications (quoting Appointment No. 462/121) should be addressed by **November 20, 1959.**

APPOINTMENTS VACANT

A JUNIOR CHEMIST is required by the Printing, Packaging & Allied Trades Research Association for its Analytical Department. Experience not essential, but an interest in analytical chemistry desirable. Wage about £300. (Ref. JC/AD).

Application forms for vacancy from the Secretary, Patra House, Randalls Road, Leatherhead.

ELECTRONIC ENGINEER. We require an experienced Electronic Engineer to operate a Sales/Consultancy service for our Analogue Computer division. This is a senior appointment and the successful applicant, who should be used to dealing with principals, will be encouraged to assist in the design and development of new ancillary equipment. Please reply giving brief history to General Manager, Louis Newmark Ltd, Prefect Works, Purley Way, Croydon.

ASSISTANT with Inter-B.Sc. or "A" level G.C.E. with Physics and Mathematics, to assist in research on the physics of letterpress printing. Salary £300–£635 p.a., 5-day week. Application forms from Secretary, The Printing, Packaging & Allied Trades Research Association, Patra House, Randalls Road, Leatherhead. Ref. LA/SP.

LECTURES AND COURSES

FARADAY HOUSE ELECTRICAL ENGINEERING COLLEGE

A THREE-YEAR COURSE, commencing each term, in Electrical Engineering to qualify for Associate of Faraday House and Graduate of the Institution of Electrical Engineers, followed by one year's practical training in Industry to qualify for the Diploma of Faraday House. For Prospectus apply to Department "E", Faraday House Electrical Engineering College, 66 Southampton Row, London, W.C.1.

SOCIETIES

THE BRITISH INTERPLANETARY SOCIETY
12 Bessborough Gardens, London, S.W.1

MEMBERSHIP and Fellowship is open to all interested in space-flight, rocket engineering and astronomy.

Full particulars of membership, together with a free copy of the Society's Journal and programme of lectures in London and many provincial towns, will be sent on request.

B.Sc.
Degree

Study at Home

The increasing importance of Science in industry, commerce and education opens up many worth-while opportunities for Science graduates. Wolsey Hall (est. 1894) provides postal tuition for the much sought-after B.Sc. degree of London University. Tuition can also be arranged for certain subjects at M.Sc. (Maths). **Prospectus** (please mention exam. or subject) from E. W. Shaw Fletcher, C.B.E., LL.B., Director of Studies, Dept. WM8,

WOLSEY HALL, OXFORD

Some forthcoming articles in
DISCOVERY

★

A New Projection Television System: the Eidophor by J. H. M. Sykes

Malaria the Killer
by J. L. Cloudsley-Thompson, M.A., Ph.D., F.C.S.

Man Makes the Cloth: Clothes Make the Man
by E. T. Renbourn, B.Sc., M.R.C.P., M.D.

★

Subscription inquiries should be addressed to
DISCOVERY JARROLD & SONS LTD, ST. JAMES, NORWICH

Printed and published in Great Britain by Jarrold & Sons Ltd, Norwich

Editorial Office: 11 Gate Street, Kingsway, W.C.2

magnus pyke

about chemistry

In this book Magnus Pyke reduces the vastly complicated subject of chemistry to basic essentials in order to explain in ordinary language the remarkable achievements that are seen all around us. The principles of chemistry and how they have been applied to modern needs is illustrated by the revolutionary developments in the chemical industry which have resulted in the manufacture of new materials such as synthetic rubbers, perspex, polythene, terylene, nylon and the like. Dr Pyke explains the close relationship between chemistry and physics, discussing such vital topics as nuclear physics and electronics.

224 pages 68 line drawings 18s.

Oliver and Boyd

Tweeddale Court, Edinburgh, 1

PHYSICISTS, CHEMISTS, ENGINEERS, MATHEMATICIANS

required in Research and Development Establishments in

MINISTRY OF SUPPLY

mainly in Southern England

Appointments in grades of

(a) Senior Scientific Officer (£1166–£1380)

(b) Scientific Officer (£615–£1090)

Starting salary according to experience
Superannuation under F.S.S.U.

GOOD PROMOTION PROSPECTS

1st or 2nd Class Honours Degree or equivalent required, and for S.S.O. at least 3 years' post-graduate research experience.

Forms from M.L.N.S. Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.438/9A/PGD.

Memory Unlimited

I JUMPED into the first railway compartment which seemed empty: my eyes fell on a book left on the seat opposite by a previous passenger.

I took it up absent-mindedly and ran through the first lines. Five minutes later I was reading it as eagerly as a clue to a hidden treasure. I learned that everyone's memory is capable of fantastic feats; that an ordinary person if he has taught himself to control the way in which his brain stores impressions can memorize accurately long and complicated lists of facts after reading them over only once or twice. I thought I would test the truth of the statement.

I took a timetable out of my suitcase and began reading quietly in the manner prescribed, the names of about one hundred railway stations. I observed that, after reading them over a few times, I could recite the whole list off with hardly a mistake. With a little more practice I found I had committed them so completely to memory that I could remember them in the reverse order and even pick out one station from the list and say which number it was, and what were the names of the towns before and after it.

I was astonished at the memory I had acquired and spent the rest of my journey on more and more difficult experiments in memory, and reflecting how this new control I was achieving over my mind would materially help me to a greater success in life. After this I worked hard at this wonderful memory system, and within a week I found I could recall passages from books and quote them with ease; names, addresses and business appointments were remembered immediately; and in four months I had succeeded in learning Spanish.

If I have obtained from life a measure of wealth and happiness, it is to that book I owe it, for it revealed to me the workings of my brain.

Three years ago, I had the good fortune to meet its author, and I promised him to propagate his method, and today I am glad of this opportunity of expressing my gratitude to him.

I can only suppose that others wish to acquire what is, after all, the most valuable asset towards success in life.

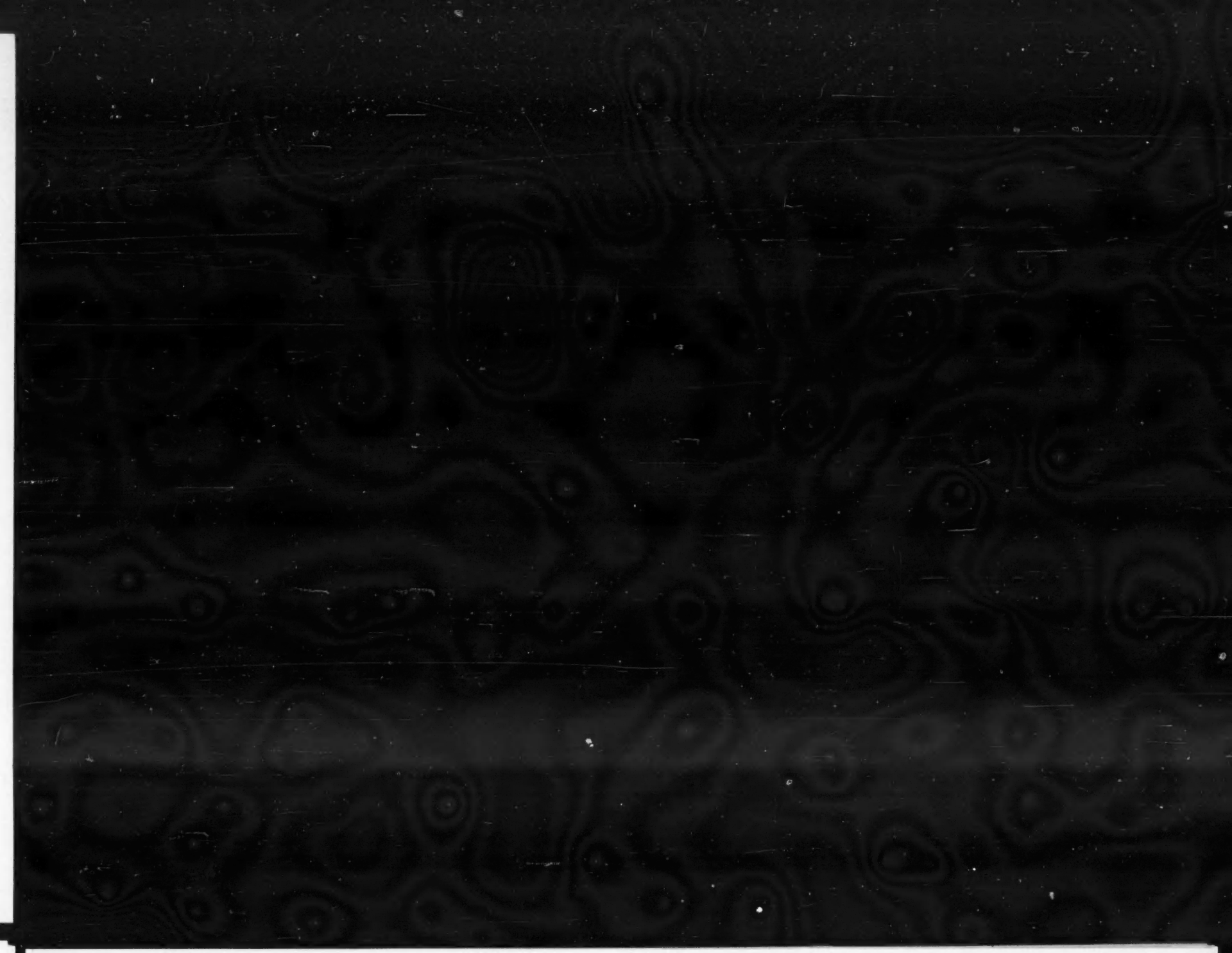
Borg's address is: B. X. BORG, C/O AUBANEL PUBLISHERS, 14 HIGHFIELD ROAD (RATHGAR), DUBLIN, IRELAND. Apply to him for his little book, "The Eternal Laws of Success". It is free to all who wish to develop their memory. F. ROBERTS

Extra cover

Oxygen is vital — we couldn't live without it — but it's not an unmixed blessing. Manufacturers of oil and petrol and users of edible oils and fats have often had cause to look askance at this life-giving gas for the trouble it causes.

When it comes into contact with petrol, the oxygen in the atmosphere brings about the formation of gummy deposits that settle on engine parts and rob cars and aeroplanes of power. In lubricating oils oxygen forms harmful acids, and in edible oils and fats it sets up a reaction that turns them rancid and destroys the vitamins. You can't abolish oxygen, but certain compounds can hamper its action, and the 'Topanol' series of anti-oxidants developed by I.C.I. do just this. Some types of 'Topanol' are added by petroleum refiners to their products to prevent the formation of gums and acids, other types keep fat-containing foods and animal feeding-stuffs fresh without affecting their wholesomeness.

In packets of biscuits, in tanks of oil, wherever oxygen's the enemy, 'Topanol' provides an extra, invisible 'wrapping' to keep it at bay.

Thus, and in a thousand kindred ways, I.C.I.'s research and production are serving the Nation.

ICI